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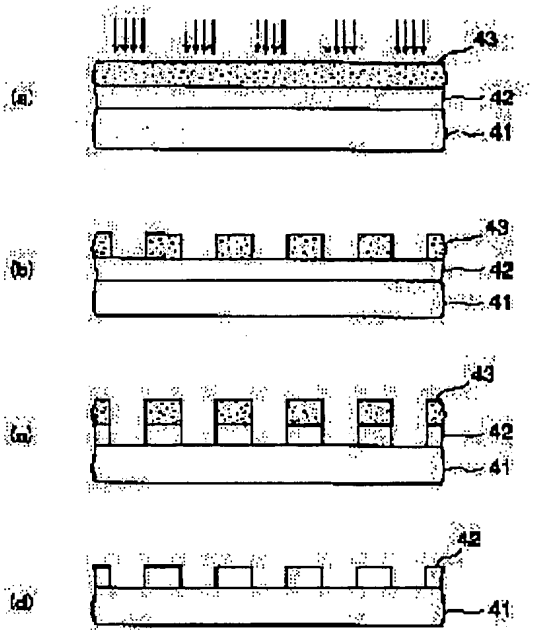
(54) EXPOSURE BASE, EXPOSURE MASK, AND MANUFACTURE OF EXPOSURE BASE

(57)Abstract:
PURPOSE: To provide an exposure base which can provide a uniform phase difference and uniform transmittance within its surface, an exposure mask, and a method for manufacturing the exposure base by adjusting the complex index of refraction the element composition ratio of a semitransparent film according to the thickness of the semitransparent film.
CONSTITUTION: In an exposure base comprising a translucent base 41 on which is a semitransparent film 42 having the desired phase difference to the base 41 and the desired transmittance, the complex index of refraction or the element composition ratio of the semitransparent film 42 is adjusted to match the thickness of the semitransparent film 42. Adjustment of the complex index of refraction of the film is performed in such a way that during film formation a distribution of reactive gas in a film forming device is provided to correspond to the speed of film formation. Adjustment of the element composition ratio of the film is achieved by performing it during film formation in such a way as to correspond to the thickness of the film being formed. Thus the complex index of refraction of the semitransparent film 42 is adjusted by adjustment of the composition ratio to correspond to a difference in thickness of the semitransparent film 42, so that a uniform phase difference and uniform intensity transmittance can be obtained within the surface of the base 41.



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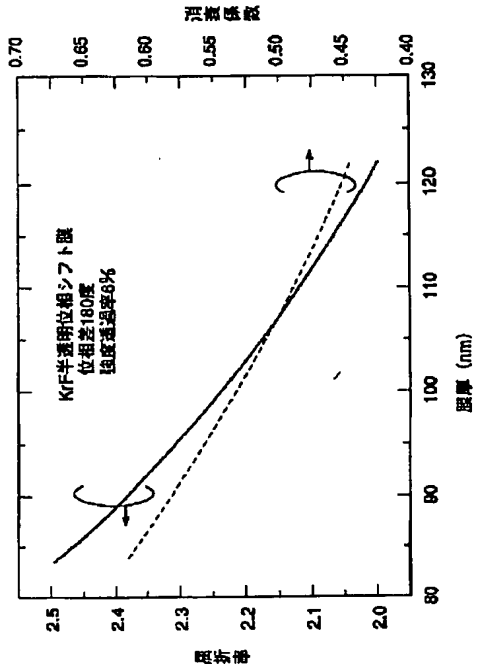
(54)【発明の名称】　露光用基板と露光用マスク及び露光用基板の製造方法

(57)【要約】
【目的】　膜厚の分布によらず、面内で均一な位相差と透過率を得ることのできる露光用マスクを提供すること。
【構成】　透光性基板上に該基板に対して所望の位相差と透過率を有する半透明膜パターンを備えた露光用マスクにおいて、半透明膜の膜厚の違いに応じて該半透明膜に光を選択的に照射し、半透明膜の元素組成比を調整するなどして半透明膜パターンの複素屈折率を調整することで、基板面内で均一な位相差と強度透過率を得ることを特徴とする。



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【特許請求の範囲】

【請求項１】透光性基板上に該基板に対して所望の位相差と透過率を有する半透明膜を備えた露光用基板において、

前記半透明膜の複素屈折率又は元素組成比が、該半透明膜の膜厚に応じて調整されてなることを特徴とする露光用基板。

【請求項２】前記半透明膜の膜厚の厚い部分で屈折率と消衰係数が小さくなるように、又は前記半透明膜の膜厚の薄い部分で屈折率と消衰係数が大きくなるように、前記半透明膜の複素屈折率又は元素組成比が調整されていることを特徴とする請求項１記載の露光用基板。

【請求項３】透光性基板上に該基板に対して所望の位相差と透過率を有する半透明膜パターンを備えた露光用マスクにおいて、

前記半透明膜パターンの複素屈折率又は元素組成比が、該半透明膜パターンの膜厚に応じて調整されてなることを特徴とする露光用マスク。

【請求項４】前記半透明膜の膜厚の厚い部分で屈折率と消衰係数が小さくなるように、又は前記半透明膜の膜厚の薄い部分で屈折率と消衰係数が大きくなるように、前記半透明膜の複素屈折率又は元素組成比が調整されていることを特徴とする請求項３記載の露光用マスク。

【請求項５】透光性基板上に該基板に対して所望の位相差と透過率を有する半透明膜を備えた露光用基板の製造方法において、

反応性ガスを用いた堆積法により前記透光性基板上に前記半透明膜を堆積する際に、堆積される半透明膜の堆積速度に応じて面内方向でガスの濃度を可変し、前記半透明膜の複素屈折率又は元素組成比を調整することを特徴とする露光用基板の製造方法。

【請求項６】前記半透明膜の堆積速度の速い部分で屈折率と消衰係数が小さくなるように、又は前記半透明膜の堆積速度の遅い部分で屈折率と消衰係数が大きくなるように、前記反応性ガスの濃度を調節することを特徴とする請求項５記載の露光用基板の製造方法。

【請求項７】透光性基板上に該基板に対して所望の位相差と透過率を有する半透明膜を備えた露光用基板の製造方法において、

前記透光性基板上に前記半透明膜を形成する工程と、次いで前記半透明膜の膜厚に応じて該半透明膜に光又は反応性ガスを選択的に照射し、前記半透明膜の複素屈折率又は元素組成比を調整する工程とを含むことを特徴とする露光用基板の製造方法。

【請求項８】前記半透明膜の膜厚の厚い部分で屈折率と消衰係数が小さくなるように、又は前記半透明膜の膜厚の薄い部分で屈折率と消衰係数が大きくなるように、前記光又はガスの照射量を調節することを特徴とする請求項７記載の露光用基板の製造方法。

【発明の詳細な説明】

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【０００１】

【産業上の利用分野】本発明は、半導体製造装置の製造工程のリソグラフィー工程に用いられる露光技術に係わり、特に半透明膜からなる位相シフタを有する露光用基板と露光用マスク及び露光用基板の製造方法に関する

【０００２】

【従来の技術】半導体技術の進歩と共に、半導体装置ひいては半導体素子は高集積化，微細化の一途を辿っている。この半導体素子の製造に際し、リソグラフィー技術は加工の要として特に重要である。現在のリソグラフィー技術では、マスクパターンを縮小光学系を介してＬＳＩ基板上に投影露光する方法が主に用いられている。このリソグラフィー技術で微細化は露光波長λの制約を大きく受け、波長以下のパターンを形成するのは非常に困難であった。これは、波長とほぼ同寸法のパターンでは隣接するパターンで干渉効果が大きく、本来暗部として形成したい領域で光強度を有し、暗部と明部の光量差が殆ど生じないことが原因となっている。このため、任意の波長を用いてＬＳＩ基板上にパターン形成を行う場合、最小線幅を波長に対し１．４倍程度の寸法に止めざるを得なかった。

【０００３】近年のＬＳＩに要求される最小線幅は、６４ｍＤＲＡＭで０．３５μｍ、更に２５６ＭｄＲＡＭでは０．２５μｍを必要とし、これらの寸法を従来のリソグラフィー技術で実現するためには、最小線幅０．３５μｍについては露光光源をＫｒＦレーザ、最小線幅０．２５μｍについてはＡｒＦレーザで対処する必要が生じる。また、これらの光源を用いた場合には対応するレジストの開発が必要となるが、これらのレジストは依然研究過程にあり実用化にはかなりの時期を必要とする。露光光源をＥＢに置き換えることも不可能ではないが、光を用いた露光と比較しスループットが大幅に低下し実用性にそぐわない。

【０００４】これらの理由から、従来の露光光源の短波長化に代わり、露光波長λを変えることなく微細化を促進させる手法について考えられるようになった。

【０００５】この目的を達成する手法として特開平４－１３６８５４公報に記載されているようにデバイス設計変更を必要としないハーフトーン型位相シフト法がある。この位相シフト法の効果を最大限に生かすには、透明部分と半透過膜を透過した光の位相差θと透過率ｔを最適化することが重要である。従来は、半透明位相シフトマスクを２層膜構造で作成していた。この手法では位相差θと透過率ｔを独立に制御しており作成が容易であった。しかし、２層構造では成膜及びエッチング工程がそれぞれ２度必要であるなど工程数が増加することや、下層膜に欠陥が生じた場合に修正が難しい等の問題が生じていた。

【０００６】また、特開平６－７５３６１号公報ではこれらの欠点を克服するために、単層膜で位相差と透過率

を同時に調整する手法が記されている。またこの手法では所望の位相差と強度透過率を満足させるために化合物の組成比を一定に保つように半透明位相シフト膜の成膜を行っている。しかし、露光用基板面内で組成比を一定で作成した場合、複素屈折率がほぼ一定の値になるため、膜厚が異なるとその違いが直接位相差と強度透過率に誤差を生み、半透明膜の位相差精度と強度透過率精度が低下するという問題が生じていた。

【０００７】

【発明が解決しようとする課題】半透明位相シフト膜においては位相差と透過率を所望の値に調整する必要がある。取り分け半透明位相シフト膜を単層で形成する場合には、一つの膜厚に対して所望の位相差と透過率を満足する複素屈折率の組み合わせは一つしか存在しない。従来法の如く露光用基板面内で組成比を一定で作成した場合、複素屈折率がほぼ一定の値になるため、膜厚が異なるとその違いが直接位相差と強度透過率に誤差を生み、半透明膜の位相差精度と強度透過率精度が低下するという問題が生じていた。

【０００８】本発明は、上記事情を考慮してなされたもので、その目的とするところは、膜厚の分布によらず、面内で均一な位相差と透過率を得ることのできる露光用基板と露光用マスク及び露光用基板の製造方法を提供することにある。

【０００９】

【課題を解決するための手段】上記課題を解決するために本発明は、次のような構成を採用している。

【００１０】即ち、本発明（請求項１）は、透光性基板上に該基板に対して所望の位相差と透過率を有する半透明膜を備えた露光用基板において、前記半透明膜の複素屈折率又は元素組成比が、該半透明膜の膜厚に応じて調整されていることを特徴とする。

【００１１】また、本発明（請求項３）は、透光性基板上に該基板に対して所望の位相差と透過率を有する半透明膜パターンを備えた露光用マスクにおいて、前記半透明膜パターンの複素屈折率又は元素組成比が、該半透明膜パターンの膜厚に応じて調整されてなることを特徴とする。

【００１２】これらの発明において、次の形態を含むことが望ましい。

【００１３】（１）前記複素屈折率の調整が、成膜時に成膜速度に対応するように成膜装置内の反応性ガス分布を持たせることで達成するようにしている。反応性ガスの分布方法については、次のうちいずれかの手法を取ることが望ましい。

【００１４】(1-1) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、成膜速度が速い部分で前記反応性ガスの濃度が他の部分と比較し高くなるように設定するようにしている。

【００１５】(1-2) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、成膜速度が速い部分で前記反応性ガスの濃度が他の部分と比較し高くなるように設定するようにしている。

【００１６】(1-3) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ前記反応性ガスが酸素又は弗素を含むガスである場合において、成膜速度が速い部分で前記反応性ガスの濃度が他の部分と比較し高くなるように設定するようにしている。

【００１７】(1-4) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、成膜速度が速い部分で前記反応性ガスの濃度が他の部分と比較し低くなるように設定するようにしている。

【００１８】(1 5) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、成膜速度が速い部分で前記反応性ガスの濃度が他の部分と比較し低くなるように設定するようにしている。

【００１９】(1-6) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ前記反応性ガスが酸素又は弗素を含むガスである場合において、成膜速度が速い部分で前記反応性ガスの濃度が他の部分と比較し低くなるように設定するようにしている。

【００２０】（２）前記複素屈折率の調整が、少なくとも成膜時に加熱処理を行い、且つ膜厚に対応するように露光用基板内の温度分布を持たせることで達成するよう

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にしている。温度分布については、次のうちいずれかの手法を取ることが望ましい。

【００２１】(2-1) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、膜厚の厚い部分で他の部分と比較し高温部分を持たせるようにしている。

【００２２】(2-2) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、膜厚の厚い部分で他の部分と比較し高温部分を持たせるようにしている。

【００２３】(2-3) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、膜厚の厚い部分で他の部分と比較し高温部分を持たせるようにしている。

【００２４】（３）前記複素屈折率の調整が、少なくとも成膜した後の処理において、成膜時の膜厚に対応するように処理装置内で反応性ガス分布を持たせることで達成するようにしている。反応性ガスの分布方法については、次のうちいずれかの手法を取ることが望ましい。

【００２５】(3-1) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、膜厚が厚い部分で前記反応性ガスの濃度が他の部分と比較し高くなるように設定するようにしている。

【００２６】(3-2) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、膜厚が厚い部分で前記反応性ガスの濃度が他の部分と比較し高くなるように設定するようにしている。

【００２７】(3-3) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ前記反応性ガスが酸素又は弗素を含むガスである場合において、膜厚が厚い部分で前記反応性ガスの濃度が他の部分と比較し高くなるように設定するようにしている。

【００２８】(3-4) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、膜厚が厚い部分で前記反応性ガスの濃度が他の部分と比較し低くなるように設定するようにしている。

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【００２９】(3-5) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、膜厚が厚い部分で前記反応性ガスの濃度が他の部分と比較し低くなるように設定するようにしている。

【００３０】(3-6) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ前記反応性ガスが酸素又は弗素を含むガスである場合において、膜厚が厚い部分で前記反応性ガスの濃度が他の部分と比較し低くなるように設定するようにしている。

【００３１】（４）前記複素屈折率の調整が、少なくとも成膜後に加熱処理を行い、且つ膜厚に対応するように露光用基板内の温度分布を持たせることで達成するようにしている。温度分布については、次のうちいずれかの手法を取ることが望ましい。

【００３２】(4-1) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、膜厚の厚い部分で他の部分と比較し高温部分を持たせるようにしている。

【００３３】(4-2) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、膜厚の厚い部分で他の部分と比較し高温部分を持たせるようにしている。

【００３４】(4-3) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、膜厚の厚い部分で他の部分と比較し高温部分を持たせるようにしている。

【００３５】（５）前記複素屈折率の調整が、少なくとも成膜後に光照射処理を行い、且つ膜厚に対応するように露光用基板内の照射量分布を持たせることで達成するようにしている。照射波長及び照射量分布については、次のうちいずれかの手法を取ることが望ましい。

【００３６】(5-1) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、３６５ｎｍ以下の光を照射し、且つ膜厚の厚い部分で他の部分と比較し照射量が多くなるようにしている。

【００３７】(5-2) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の

半透明膜を作成するときに、２４８ｎｍ以下の光を照射し、且つ膜厚の厚い部分で他の部分と比較し照射量が多くなるようにしている。

【００３８】(5-3) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、２４８ｎｍ以下の光を照射し、且つ膜厚の厚い部分で他の部分と比較し照射量が多くなるようにしている。

【００３９】（６）前記元素組成比の調整が、成膜時に成膜時の膜厚に対応するように調整することで達成するようにしている。元素組成比の分布方法については、次のうちいずれかの手法を取ることが望ましい。

【００４０】(6-1) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ成膜速度が速い部分で他の部分と比較し酸素，窒素，弗素，又は水素の金属乃至はＩＶ族元素に対する組成比が高くなるように設定するようにしている。

【００４１】(6-2) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ成膜速度が速い部分で他の部分と比較し酸素，窒素，弗素，又は水素の金属乃至はＩＶ族元素に対する組成比が高くなるように設定するようにしている。

【００４２】(6-3) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ成膜速度が速い部分で他の部分と比較し酸素又は弗素の金属乃至はＩＶ族元素に対する組成比が高くなるように設定するようにしている。

【００４３】(6-4) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ成膜速度が速い部分で他の部分と比較し酸素，窒素，弗素，又は水素の金属乃至はＩＶ族元素に対する組成比が低くなるように設定するようにしている。

【００４４】(6-5) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ成膜速度が速い部分で他の部分と比較し酸素，窒素，弗素，又は水素の金属乃至はＩＶ族元素に対する組成比が低くなるように設定するようにしている。

【００４５】(6-6) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ成膜速度が速い部分で他の部分と比較し酸素又は弗素の金属乃至はＩＶ族元素に対する組成比が低くなるように設定するようにしている。

【００４６】（７）前記元素組成比の調整が、成膜時に成膜時の膜厚に対応するように成膜装置内の反応性ガス分布を持たせることで達成するようにしている。反応性ガスの分布方法については、次のうちいずれかの手法を取ることが望ましい。

【００４７】(7-1) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、成膜速度が速い部分で他の部分と比較し前記反応性ガスの濃度が高くなるように設定するようにしている。

【００４８】(7-2) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、成膜速度が速い部分で他の部分と比較し前記反応性ガスの濃度が高くなるように設定するようにしている。

【００４９】(7-3) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ前記反応性ガスが酸素又は弗素を含むガスである場合において、成膜速度が速い部分で他の部分と比較し前記反応性ガスの濃度が高くなるように設定するようにしている。

【００５０】(7-4) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、成膜速度が速い部分で他の部分と比較し前記反応性ガスの濃度が低くなるように設定するようにしている。

【００５１】(7-5) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０%の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、成膜速度が速い部分で他の部分と比較し前記反応性ガスの濃度が低くなるように設定するようにしている。

【００５２】(7-6) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０%の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ前記反応性ガスが酸素又は弗素を含むガスである場合において、成膜速度が速い部分で他の部分と比較し前記反応性ガスの濃度が低くなるように設定するようにしている。

【００５３】（８）前記元素組成比の調整が、成膜後に成膜時の膜厚に対応するように調整することで達成するようにしている。元素組成比の分布方法については、次のうちいずれかの手法を取ることが望ましい。

【００５４】(8-1) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０%の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ膜厚が厚い部分で酸素，窒素，弗素，又は水素の金属乃至ＩＶ族元素に対する組成比が他の部分と比較し高くなるように設定するようにしている。

【００５５】(8-2) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０%の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ膜厚が厚い部分で酸素，窒素，弗素，又は水素の金属乃至ＩＶ族元素に対する組成比が他の部分と比較し高くなるように設定するようにしている。

【００５６】(8-3) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０%の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ膜厚が厚い部分に対して酸素又は弗素の金属乃至はＩＶ族元素に対する組成比が他の部分と比較し高くなるように設定するようにしている。

【００５７】(8-4) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０%の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ膜厚が厚い部分で酸素，窒素，弗素，又は水素の金属乃至ＩＶ族元素に対する組成比が他の部分と比較し低くなるように設定するようにしている。

【００５８】(8-5) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０%の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ膜厚が厚い部分で酸素，窒素，弗素，又は水素の金属乃至ＩＶ族元素に対する組成比が他の部分と比較し低くなるように設定するようにしている。

【００５９】(8-6) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０%の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ膜厚が厚い部分に対して酸素又は弗素の金属乃至はＩＶ族元素に対する組成比が他の部分と比較し低くなるように設定するようにしている。

【００６０】（９）前記元素組成比の調整が、成膜後に成膜時の膜厚に対応するように少なくとも反応性ガス雰囲気中に晒し且つ前記反応性ガスに分布を持たせることで達成するようにしている。反応性ガスの分布方法については、次のうちいずれかの手法を取ることが望ましい。

【００６１】(9-1) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０%の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、膜厚が厚い部分で前記反応性ガスの濃度が他の部分と比較し高くなるように設定するようにしている。

【００６２】(9-2) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０%の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、膜厚が厚い部分で前記反応性ガスの濃度が他の部分と比較し高くなるように設定するようにしている。

【００６３】(9-3) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０%の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が小さくなる性質を有し、且つ前記反応性ガスが酸素又は弗素を含むガスである場合において、膜厚が厚い部分で前記反応性ガスの濃度が他の部分と比較し

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高くなるように設定するようにしている。

【００６４】(9-4) 波長３６５ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、膜厚が厚い部分で前記反応性ガスの濃度が他の部分と比較し低くなるように設定するようにしている。

【００６５】(9-5) 波長２４８ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率と消衰係数が大きくなる性質を有し、且つ前記反応性ガスが酸素，窒素，弗素，又は水素を含むガスである場合において、膜厚が厚い部分で前記反応性ガスの濃度が他の部分と比較し低くなるように設定するようにしている。

【００６６】(9-6) 波長１９３ｎｍにおける露光用基板の中心部１２ｃｍ角内の平均強度透過率が４～２０％の半透明膜を作成するときに、半透明膜の組成で酸素，窒素，弗素，又は水素の組成比が大きくなることで屈折率＊

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＊と消衰係数が大きくなる性質を有し、且つ前記反応性ガスが酸素又は弗素を含むガスである場合において、膜厚が厚い部分で前記反応性ガスの濃度が他の部分と比較し低くなるように設定するようにしている。

【００６７】

【作用】本発明に関し、透光性基板の開口部に対し所望の透過率ｔと位相差θを得ることのできる単層半透明膜を得る条件及び具体的手法について述べる。

【００６８】半透明膜を単層で用いようとした場合、半透明膜を透過する光の位相を透明な部分を透過する光の位相に対し１８０°に制御することが必要で、かつ半透明膜の透過率ｔを所望の値にすることが必要である。

【００６９】半透明膜の位相シフトマスクで最大の解像度を得るためには、半透明膜の光学定数は次の条件を満たす必要がある。

【００７０】膜の位相差θ及び透過率ｔを求めるには、膜の特性マトリクスを用いた多重干渉計算を行うのが非常に有効である。いま、半透明膜の屈折率をｎ、消衰係数をｋ、膜厚をｄとし、露光光が半透明膜に垂直に入射する場合を考えると、半透明膜の特性マトリクスは（式１）のように表すことができる。

【００７１】

【数１】

$$[M]=\begin{bmatrix} m11 & m12 \\ m21 & m22 \end{bmatrix}=\begin{bmatrix} \cos\delta & \frac{i\sin\delta}{n-ik} \\ i(n-ik)\sin\delta & \cos\delta \end{bmatrix} \quad (式1)$$

【００７２】ここで、δは（式２）のように与えられる。

※【００７３】

※　【数２】

$$\delta=2\pi n d/\lambda \quad (式2)$$

【００７４】この特性マトリクスを用い、更に半透明膜と石英基板の境界面上の電場Ｅ₀，磁場Ｈ₀は半透明膜★

★と空気境界面上の電場Ｅ₁，磁場Ｈ₁を用いて

【数３】

$$\begin{bmatrix} E_0 \\ H_0 \end{bmatrix}=[M]\begin{bmatrix} E_1 \\ H_1 \end{bmatrix} \quad (式3)$$

【００７５】と表すことができる。ところで、基板が露光波長λに対し十分厚いことを考え、基板で多重干渉が生じないことを考慮すると、基板側から近づけた境界面上の透過波の電磁場の接線成分をＥ₂＇とＨ₂＇＝Ｅ₂☆

☆＇ Y_2 とおくと、境界条件から$E_1=E_2'$，$H_1=H_2'$となるから

【数４】

$$\begin{bmatrix} E_0^{+}+E_0^{-} \\ (E_0^{+}-E_0^{-})\,n_0 \end{bmatrix}=[M]\begin{bmatrix} E_2^{+} \\ E_2^{+}n_2 \end{bmatrix} \quad (式4)$$

【００７６】を得る。これより複素透過率ｔ＇は（式５）と表せる。

◆【００７７】

◆　【数５】

$$t'=\frac{E_2^{+}}{E_0^{+}}=\frac{2n_0}{n_0(m11+n_2\,m12)+(m21+n_2\,m22)} \quad (式5)$$

【００７８】更にｔから強度透過率ｔと位相φを求める　と

【数６】

$$t = (t'\text{の実部})^2 + (t'\text{の虚部})^2 \qquad (式6)$$

$$\phi = \tan^{-1}(t'\text{の虚部} / t'\text{の実部}) \qquad (式7)$$

【００７９】を得る。このようにして得た半透明膜の強度透過率ｔ及び位相φと、半透明膜と同一の厚さの空気で得られる強度透過率ｔと位相の相対値θを求めることで、この半透明膜をマスクパターンに適用したときの透過率ｔと位相差θを求めることができる。なお、この算出式は単層半透明位相シフト膜に対してのみではなく、多層半透明（一部透明膜を含む）位相シフト膜についても適用可能である。

【００８０】これらの式より半透明位相シフト膜を単層で形成する場合の膜厚に対する屈折率と消衰係数の関係を求めた結果を、図１に示す。図１は、ＫｒＦエキシマレーザを露光光源に用いることを前提とした位相差１８０度、強度透過率６％の半透明膜の例である。図１に示すように膜厚が定まると、所望の位相差と強度透過率を得るための屈折率と消衰係数が一様に定まる。

【００８１】半透明膜の成膜が理想的な状態で行われた場合、図２に示すように膜厚が、図３に示すように複素屈折率が露光用マスク面内で共に一定となるが、この場合は図４に示す如く位相，強度透過率共に面内で一定の値となる。図４は露光用マスクの中心を０とし、この点を基準として±１０ｃｍの範囲の値を示している。この図に示す如く理想的な場合には、露光用マスク全体で均一な位相差と強度透過率を得ることが可能である。

【００８２】しかし、一般に半透明位相シフト膜の成膜では基板面内で膜厚の不均一性が生じる。例えば図５は同心円上に磁場をかけて基板中心で位相差１８０度、強度透過率６％となるようにスパッタ法で成膜したときの膜厚分布を示したものだが、基板中心より若干外側の部分で膜厚が厚く、更に外側で膜厚が薄くなる傾向を持つ。膜厚が図５の分布を持ち、且つ図６のように一様な複素屈折率分布を持つ場合、位相差と透過率の基板面内分布（±１０ｃｍ□、以下特に断らない場合はこの領域の面内分布とする）は図７のような分布となる。

【００８３】図７で位相差は１８０度－１０度の分布を、また強度透過率は６＋１％の分布を持つ。従来の手法では、位相差と強度透過率の露光用基板面内分布は膜厚変動に大きく依存する傾向にあった。

【００８４】一方、本発明では膜厚変動に対応するように複素屈折率を調整することで位相差については１８０±２．５度、強度透過率６％±０．２５％と、基板面内の位相差を平均位相差に対して±２．５度の範囲に、また基板面内の強度透過率を平均透過率に対して±２．５度の範囲に収めることを可能にした。

【００８５】ここで、膜厚に対応するように複素屈折率を調整することは、任意の基準膜厚に対して、基準膜厚より膜厚の厚い部分で複素屈折率を基準膜厚における値より小さく（屈折率、消衰係数を共に小さく）するか、或いは任意の基準膜厚に対して、基準膜厚より膜厚の薄い部分で複素屈折率を基準膜厚における値より大きく（屈折率、消衰係数を共に大きく）することを言う。

【００８６】

【実施例】以下、本発明について実施例を用いて詳細に説明する。

【００８７】（実施例１）本実施例は、半透明膜にｇ線，ｉ線，及びＫｒＦ線等に適用されるＳｉＮｘ膜（ｘは任意の組成比）を用いた露光用基板に関するもので、ここでは取り分けＫｒＦ用露光基板の製造方法について説明する。

【００８８】石英基板上にＳｉをターゲットとし、アルゴン・窒素の混合ガスをキャリアガスとして成膜を行った。ターゲットではスパッタがリング状に生じるよう磁場をかけた。成膜時の膜質は基板面内でほぼ均一の複素屈折率２．２５（屈折率）－０．５４（消衰係数）ｉを得ることができたが、膜厚は図８に示す如く周辺部で薄くなるような分布を示した。基板面内の位相差と透過率の分布をこれらの複素屈折率と膜厚より求めたところ、膜厚の分布を反映し基板中心で位相差が大きくまた透過率が低い傾向が得られた。

【００８９】このような位相差と透過率の分布を無くすため、成膜した透光性基板を低圧水銀ランプの下に曝露した。本処理は光が照射された部分の屈折率と消衰係数のいずれも低下させることを目的とするもので、低圧水銀ランプの波長には２５２ｎｍ及び１８７ｎｍを主成分とするものを用いた。光照射による変化は、半透明膜中に存在する未結合種（ダングリングボンド）がその吸収帯に含まれる波長の光を吸収し、結合することでダングリングボンド数を少なくすることによるものであった。

【００９０】低圧水銀ランプとしては、図９に示すように、被成膜基板１１の膜厚の厚い部分１２に対応させ１２ｃｍ四方に放電管１３を折り曲げたものを用い、膜厚の厚い部分で照射量が多くなるようにした。

【００９１】本処理を行った後の複素屈折率の面内分布を、図１０に示す。照射前において面内で均一だった複素屈折率は照射後で中心±５ｃｍの領域で他の領域より小さくすることができた。図１０及び図８で示した複素屈折率と膜厚を測定した同じ場所で半透明膜の透過率と位相差を測定したところ、図１１の結果を得た。図１１で示されるように、透光性基板面内で均一な特性（位相

差：１８０度±２．５度、強度透過率：中心値（６％）±０．２％）を得ることができた。

【００９２】従来の手法では膜厚分布と複素屈折率分布の間に、例えば図１に示すような相関を持たせるよう処理を施さないため透過率と位相差の制御が難しいものであったが、本実施例のように成膜後に結合変化を生じさせる処理を施し、膜厚に応じた複素屈折率の分布を持たせることで、透過率と位相差の面内精度を向上させることができた。

【００９３】本実施例では成膜を反応性スパッタにより行ったが、これに限るものではなくＣＶＤ，蒸着など他の成膜方法で行うことも可能である。

【００９４】なお、本実施例ではＳｉＮｘ膜の製造方法について示したが、これに限るものではなく、ダングリングボンドを含む半透明膜に適用可能で、例えばＳｉＯｘ，ＳｉＯｘＮｙ，ＣｒＯｘ，ＣｒＮｘ，ＣｒＯｘＮｙ，ＡｉＯｘ，ＡｌＮｘ，ＡｉＯｘＮｙ，ＣａＦｘ，ＭｇＦｘ等金属、又は半導体の酸化物，窒化物，酸窒化物，弗化物を含む半透明膜や、ＭｏＳｉＯｘ，ＭｏＳｉＮｘ，ＭｏＳｉＯｘＮｙ，ＷＳｉＯｘ，ＷＳｉＯｘＮｙ，ＮｉＳｉＯｘ，ＮｉＳｉＮｘ，ＮｉＳｉＯｘＮｙ等の金属シリサイドの酸化物，窒化物，酸窒化物，弗化物を含む半透明膜に対しても適用可能である。（ｘ，ｙは任意の組成比）

また、ダングリングボンド数を変化させるのに用いる光源は、半透明膜の吸収帯の少なくとも一部に属する波長を含むものであれば如何なる光源でもよい。光源の形状も環状に限るものではなく、球状，楕形など膜厚分布に応じて、即ち膜厚が厚くなるに従い照度が大きくなるよう光源の形を設定すればいかなる形態のものも適用可能である。光源又は基板を光照射中に中心回転若しくは変心回転させてもよい。加熱することによっても同様の効果を得ることが可能である。光照射と加熱を組み合わせてもよい。更に、これら光照射と加熱の処理時間は所望の複素屈折率ひいては所望の位相差と透過率を満たすように設定することが好ましい。

【００９５】本実施例では、基板中心部が周囲と比べて膜厚が厚い場合について述べたが、周囲の膜厚が厚い場合でも膜厚が厚い部分で複素屈折率の実部と虚部、即ち屈折率と消衰係数が膜厚の薄い部分より小さくなるよう構成することで適用できる。本実施例はＫｒＦ露光用基板に関するものであるが、これに限るものではなくＸ線等を含め如何なる露光波長に対する半透明膜についても適用可能である。

【００９６】また、透光性基板上にＣｒ又はＭｏＳｉ等の遮光膜が少なくとも一部に形成された基板についても適用可能である。半透明膜の下に遮光膜が具備された露光用基板については、露光用基板に予め遮光膜が設けられた露光用基板にレジストを塗布し光又は電子線による選択露光を行い、不要部の遮光膜を除去した露光用基板に対して本実施例に従い半透明膜を形成するとよい。また、半透明膜の上に遮光膜が具備された露光用基板については、本実施例に従い半透明膜を形成した後に、遮光膜をスパッタ或いはＣＶＤ，蒸着等により形成するとよい。

【００９７】また、本実施例は膜内で均一な位相と透過率を持つような半透明膜作成方法に関するものであるが、半透明膜の一部が少なくとも異なる透過率になるように調整してもよい。部分的に透過率を調整する場合には、集束した光を局部的に照射することで達成することが可能である。この処理は露光用基板作成時に行ってもよいが、半透明パターン形成後に行ってもよい。このように部分的に透過率を調整することは、パターン領域内で露光の際に用いるウエハとのアライメントマーク、レチクルとのアライメントマーク及びパターン形成領域と非形成領域の境界部分に適用することが好ましい。

【００９８】なお、本実施例では露光用マスクの目標透過率を６％としたが、これに限るものではなく、４～２０％の範囲であれば如何なる透過率に対しても適用可能である。

【００９９】（実施例２）本実施例は、半透明膜にｇ線，ｉ線，及びＫｒＦ線等に適用されるＳｉＮｘ膜（ｘは任意の組成比）を用いた露光用基板に関するもので、ここでは取り分けＫｒＦ用露光基板の製造方法について説明する。

【０１００】石英基板上にＳｉをターゲットとし、アルゴン・窒素の混合ガスをキャリアガスとして成膜を行った。ターゲットではスパッタがリング状に生じるよう磁場をかけた。成膜時の膜質は基板面内でほぼ均一の複素屈折率２．１５（屈折率）－０．６（消衰係数）ｉを得ることができたが、膜厚は図１２に示す如く周辺部で厚くなるような分布を示した。基板面内の位相差と透過率の分布をこれらの複素屈折率と膜厚より求めたところ、膜厚の分布を反映し基板中心で位相差が小さくまた透過率が高い傾向が得られた。

【０１０１】このような位相差と透過率の分布を無くすため、成膜した透光性基板を酸素雰囲気中で低圧水銀ランプの下に曝露した。本処理は光が照射された部分の屈折率と消衰係数のいずれも低下させることを目的とするもので、低圧水銀ランプの波長には２５２ｎｍ及び１８７ｎｍを主成分とするものを用いた。光照射による変化は半透明膜中に存在する未結合種（ダングリングボンド）がその吸収帯に含まれる波長の光を吸収し、結合することでダングリングボンド数を少なくすることによるものであった。

【０１０２】低圧水銀ランプとしては、図１３に示すように、被成膜基板２１の膜厚の厚い部分２２に対応させて環状構造の放電管２３を用い、膜厚の厚い部分で照射量が多くなるようにした。なお、環の直径は１８ｃｍとし、膜厚が厚い部分に対応するようにした。

【０１０３】本処理を行った後の複素屈折率を、図１４に示す。照射前において面内で均一だった複素屈折率は照射後で中心±５ｃｍより外側の領域で他の領域より小さくすることができた。図１４に示した複素屈折率を測定した同じ場所で半透明膜の透過率と位相差を測定したところ、図１５の結果を得た。図１５で示されるように、透光性基板面内で均一な特性（位相差：１８０度±２度、強度透過率：中心値（５％）±０．２％）を得ることができた。

【０１０４】従来の手法では膜厚分布と複素屈折率分布の間に、例えば図１に示すような相関を持たせるよう処理を施さないため透過率と位相差の制御が難しいものであったが、本実施例のように成膜後に組成または結合状態を変化させる処理を施し、膜厚に応じた元素組成比、即ち膜厚の厚い部分で酸素を多く含ませることで、複素屈折率の分布を生じさせ、それにより透過率と位相差の面内精度を向上させることができた。

【０１０５】本実施例では成膜を反応性スパッタにより行ったが、これに限るものではなくＣＶＤ，蒸着など他の成膜方法で行うことも可能である。

【０１０６】なお、本実施例ではＳｉＮｘ膜の製造方法について示したが、これに限るものではなく、ダングリングボンドを含む半透明膜に適用可能で、例えばＳｉＯｘ，ＳｉＯｘＮｙ，ＣｒＯｘ，ＣｒＮｘ，ＣｒＯｘＮｙ，ＡｉＯｘ，ＡｌＮｘ，ＡｉＯｘＮｙ，ＣａＦｘ，ＭｇＦｘ等金属、又は半導体の酸化物，窒化物，酸窒化物，弗化物を含む半透明膜や、ＭｏＳｉＯｘ，ＭｏＳｉＮｘ，ＭｏＳｉＯｘＮｙ，ＷＳｉＯｘ，ＷＳｉＯｘＮｙ，ＮｉＳｉＯｘ，ＮｉＳｉＮｘ，ＮｉＳｉＯｘＮｙ等の金属シリサイドの酸化物，窒化物，酸窒化物，弗化物を含む半透明膜に対しても適用可能である。（ｘ，ｙは任意の組成比）

また、ダングリングボンド数を変化させるのに用いる光源は、半透明膜の吸収帯の少なくとも一部に属する波長を含むものであれば如何なる光源でもよい。光源の形状も環状に限るものではなく、球状，櫛形など膜厚分布に応じて、即ち膜厚が厚くなるに従い照度が大きくなるよう光源の形を設定すればいかなる形状のものも適用可能である。光源又は基板を光照射中に中心回転若しくは変心回転させてもよい。加熱することによっても同様の効果を得ることが可能である。光照射と加熱を組み合わせてもよい。更に、これら光照射と加熱の処理時間は所望の複素屈折率しいては所望の位相差と透過率を満たすように設定することが好ましい。

【０１０７】本実施例では酸素の組成に分布を持たせたが、これに限るものではなく窒素，弗素，水素等を用い、その組成について分布をもたせ本願の目的を達成することもできる。

【０１０８】本実施例では、基板中心部が周囲と比べて膜厚が厚い場合について述べたが、周囲の膜厚が厚い場合でも膜厚が厚い部分で複素屈折率の実部と虚部、即ち屈折率と消衰係数が膜厚の薄い部分より小さくなるよう構成すればよい。

【０１０９】さらには、窒素，酸素，弗素，又は水素の組成を高めることで複素屈折率の実部と虚部、即ち屈折率と消衰係数が小さくなるとき、膜厚の厚い部分で窒素，酸素，弗素，又は水素の組成比を膜厚の薄い部分より相対的に高めるように構成することで適用可能である。

【０１１０】さらには、窒素，酸素，弗素，又は水素の組成を高めることで複素屈折率の実部と虚部、即ち屈折率と消衰係数が大きくなるとき、膜厚の厚い部分で窒素，酸素，弗素，又は水素の組成比を膜厚の薄い部分より相対的に低めるように構成すればよい。

【０１１１】本実施例はＫｒＦ露光用基板に関するものであるが、これに限るものではなくＸ線等を含め如何なる露光波長に対する半透明膜についても適用可能である。

【０１１２】また、透光性基板上にＣｒ又はＭｏＳｉ等の遮光膜が少なくとも一部に形成された基板についても適用可能である。半透明膜の下に遮光膜が具備された露光用基板については、露光用基板に予め遮光膜が設けられた露光用基板にレジストを塗布し光又は電子線による選択露光を行い、不要部の遮光膜を除去した露光用基板に対して本実施例に従い半透明膜を形成するとよい。また、半透明膜の上に遮光膜が具備された露光用基板については、本実施例に従い半透明膜を形成した後に、遮光膜をスパッタ或いはＣＶＤ，蒸着等により形成するとよい。

【０１１３】また、本実施例は膜内で均一な位相と透過率を持つような半透明膜作成方法に関するが、半透明膜の一部が少なくとも異なる透過率になるように調整してもよい。部分的に透過率を調整する場合には集束した光を局部的に照射することで達成することが可能である。この処理は露光用基板作成時に行ってもよいが、半透明パターン形成後に行ってもよい。このように部分的に透過率を調整はパターン領域内で露光の際に用いるウエハとのアライメントマーク、レチクルとのアライメントマーク及びパターン形成領域と非形成領域の境界部分に適用することが好ましい。

【０１１４】なお、本実施例では露光用マスクの目標透過率を５％としたが、これに限るものではなく、４～２０％の範囲であれば如何なる透過率に対しても適用可能である。

【０１１５】（実施例３）本実施例は、半透明膜にｇ線，ｉ線，及びＫｒＦ線等に適用されるＳｉＮｘ膜（ｘは任意の組成比）を用いた露光用基板に関するもので、ここでは取り分けｉ線用露光基板の製造方法について説明する。

【０１１６】石英基板上にＳｉをターゲットとし、アル

ゴン・窒素の混合ガスをキャリアガスとして成膜を行った。ターゲットではスパッタがリング状に生じるように磁場をかけた。また、混合ガスの導入をターゲットの中心部より行い、ターゲットの中心部と被成膜基板の中心部を一致させることで、被成膜基板の中心部で窒素濃度が高くなるようにした。

【０１１７】なお、膜厚は図１６に示す如く周辺部で薄くなるような分布を示した。複素屈折率は図１７に示すように中心部で屈折率、消衰係数共に低くなる分布を得た。図１７に示した複素屈折率を測定した同じ場所で半透明膜の透過率と位相差を測定したところ、図１８の結果を得た。図１８で示されるように透光性基板面内で均一な特性（位相差：１８０度±１度、強度透過率：中心値（８％）±０．１％）を得ることができた。

【０１１８】従来の手法では膜厚分布と複素屈折率分布の間に、例えば図１に示すような相関を持たせるよう処理を施さないため透過率と位相差の制御が難しいものであったが、本実施例のように成膜時に組成又は結合状態を調整することで、膜厚に応じた元素組成比、即ち膜厚の厚い部分で窒素を多く含ませて複素屈折率の分布を生じさせ、それにより透過率と位相差の面内精度を向上させることができた。

【０１１９】本実施例では成膜を反応性スパッタにより行ったが、これに限るものではなくＣＶＤ，蒸着など他の成膜方法で行うことも可能である。

【０１２０】なお、本実施例ではＳｉＮｘ膜の製造方法について示したが、これに限るものではなく、ダングリングボンドを含む半透明膜に適用可能で、例えばＳｉＯｘ，ＳｉＯｘＮｙ，ＣｒＯｘ，ＣｒＮｘ，ＣｒＯｘＮｙ，ＡｉＯｘ，ＡｌＮｘ，ＡｉＯｘＮｙ，ＣａＦｘ，ＭｇＦｘ等金属、又は半導体の酸化物，窒化物，酸窒化物，弗化物を含む半透明膜や、ＭｏＳｉＯｘ，ＭｏＳｉＮｘ，ＭｏＳｉＯｘＮｙ，ＷＳｉＯｘ，ＷＳｉＯｘＮｙ，ＮｉＳｉＯｘ，ＮｉＳｉＮｘ，ＮｉＳｉＯｘＮｙ等の金属シリサイドの酸化物，窒化物，酸窒化物，弗化物を含む半透明膜に対しても適用可能である。（ｘ，ｙは任意の組成比）

また、複素屈折率の微調整を実施例１で示した成膜後に行った後処理と同様の手法で行ってもよい。さらに、組成比の微調整を実施例２で示した成膜後に行った後処理と同様の手法で行ってもよい。

【０１２１】また、本実施例では窒素の組成に分布を持たせたが、これに限るものではなく膜の材料に応じ、また最終的に得ようとする半透明膜の組成に応じ、その組成に含まれる窒素，弗素，水素等を用い、成膜時の反応ガスのチャンバー内分布又は半透明膜の各位置に対する組成分布をもたせ本願の目的を達成すればよい。

【０１２２】本実施例では基板中心部が周囲と比べて膜厚が厚い場合について述べたが、周囲で膜厚が厚い場合でも膜厚が厚い部分で複素屈折率の実部と虚部、即ち屈折率と消衰係数が膜厚の薄い部分より小さくなるよう構成すればよい。

【０１２３】さらには、窒素，酸素，弗素，又は水素の組成を高めることで複素屈折率の実部と虚部、即ち屈折率と消衰係数が小さくなるとき、膜厚の厚い部分で窒素，酸素，弗素，又は水素の組成比を膜厚の薄い部分より相対的に高めるように構成すればよい。

【０１２４】さらには、窒素，酸素，弗素，又は水素の組成を高めることで複素屈折率の実部と虚部、即ち屈折率と消衰係数が大きくなるとき、膜厚の厚い部分で窒素，酸素，弗素，又は水素の組成比を膜厚の薄い部分より相対的に低めるように構成すればよい。

【０１２５】本実施例はＫｒＦ露光用基板に関するものであるが、これに限るものではなくＸ線等を含め如何なる露光波長に対する半透明膜についても適用可能である。

【０１２６】また、透光性基板上にＣｒ又はＭｏＳｉ等の遮光膜が少なくとも一部に形成された基板についても適用可能である。半透明膜の下に遮光膜が具備された露光用基板については、露光用基板に予め遮光膜が設けられた露光用基板にレジストを塗布し光又は電子線による選択露光を行い、不要部の遮光膜を除去した露光用基板に対して本実施例に従い半透明膜を形成するとよい。また、半透明膜の上に遮光膜が具備された露光用基板については、本実施例に従い半透明膜を形成した後に、遮光膜をスパッタ或いはＣＶＤ，蒸着等により形成するとよい。

【０１２７】また、本実施例は膜内で均一な位相と透過率を持つような半透明膜作成方法に関するが、半透明膜の一部が少なくとも異なる透過率になるように調整してもよい。部分的に透過率を調整する場合には、集束した光を局部的に照射することで達成することが可能である。この処理は露光用基板作成時に行ってもよいが、半透明パターン形成後に行ってもよい。このように部分的に透過率を調整はパターン領域内で露光の際に用いるウエハとのアライメントマーク、レチクルとのアライメントマーク及びパターン形成領域と非形成領域の境界部分に適用することが好ましい。

【０１２８】なお、本実施例では露光用マスクの目標透過率を８％としたが、これに限るものではなく、４～２０％の範囲であれば如何なる透過率に対しても適用可能である。

【０１２９】（実施例４）本実施例は、実施例１～３で作成した露光用基板を用いて作成した露光用マスクに関する。

【０１３０】まず、図１９（ａ）に示すように、半透明膜４２が形成された透光性基板４１上に感光性樹脂材料４３を塗布し、ベイキングを行った後、光露光により描画を行った。次いで、図１９（ｂ）に示すように、光が照射された部分又は照射されない部分の一方を現像によ

り除去した後、図１９（ｃ）に示すように、露出した半透明膜４２をＣＦ４と酸素の混合ガスによるドライエッチングで除去した。最後に、図１９（ｄ）に示すように、感光性樹脂材料４３を酸素プラズマ中で酸化除去を行い、所望の露光用マスクを作成した。

【０１３１】なお、本実施例でドライエッチングを面内で均一に削れるように光学特性の応じたエッチング速度分布を持たせて行った。また、本実施例では描画に光露光を用いたが、これに限るものではなく電子線露光により行ってもよい。この場合、レジストにも電子線用レジストを用いるが、このレジストの上層或いは下層としてＳｎＯ，ＩＴＯ等の導電性材料からなる膜を設けてもよい。

【０１３２】エッチングは目的に応じて異方的に除去するか、或いは等方的に除去するかを選ぶことができる。

【０１３３】また、エッチングのガス条件は半透明膜の材質により選択すればよい。例えば本実施例のように半透明膜にＳｉを含む場合には弗素元素を含む物質を少なくとも含むガスでエッチングを行えばよい。また、Ｃｒを含む場合には塩素元素を含む物質を少なくとも含むガスでエッチングを行えばよい。

【０１３４】（実施例５）本実施例は、実施例２で作成した露光用基板を実施例４に基づき作成した露光用マスクを用いた半導体装置の製造方法に関するもので、配線等を加工するにあたりライン又はスペースパターンを作成するための手法である。

【０１３５】まず、図２０（ａ）に示すように、被加工基板５１上にＫｒＦエキシマレーザに感光性を有する感光性樹脂材料５２を膜厚約１μｍで形成した。この基板に対して、図２０（ｂ）に示すように、レンズ５３を用いてマスクパターンを観光性樹脂材料５２に転写した。具体的には、２次光源面で、光軸に対して４回対称の特定の位置からの光のみを集光するように実施例４記載の露光用マスクに入射し、そのマスクパターン像を被加工基板５１上に結像させた。なお、２次光源面の光軸に対して４回対称部に設定された開口部は、最小ピッチのライン＆スペース部が少なくとも１対存在する部分に対してその長辺方向と直交するように、４回対称部にある開口部を結んで得られる長方形又は正方形の少なくとも１辺が来るように構成されている。

【０１３６】露光の後、ウエットによる現像を行い、図２０（ｃ）に示すように、レジストパターンを形成した。本手法により、０．２５μｍパターンを焦点位置±１．５μｍの範囲で寸法変動±０．０２５μｍ以内に、チップ面内で作成することができた。なお、従来法で作成した位相差と透過率の面内精度が悪いマスクを用いた場合には、０．２５μｍパターンを焦点位置±０．７μｍの範囲でしかチップ面内で寸法変動±０．０２５μｍ以内で作成できなかった。この原因は、周囲で位相差が１８０度でないため焦点深度が小さくなったためである。

【０１３７】本実施例で示したように、本発明により作成した露光マスクを用いることで被加工基板上で幅広い焦点深度を得ることが可能で、このようなマスクを工程の少なくとも一部に用いることで電気的特性（抵抗値、電流値など）が非常に均一なマスクを作成することができた。

【０１３８】本実施例では２次光源の位置に４回軸対称部に開口部を持つ照明絞りを採用したが、これに限るものではなくｎ回軸対称部（ｎは整数）に開口部を持つ絞りを用いてもよい。また、光軸に対して環状の開口部を持つ絞りを用いてもよい。

【０１３９】（実施例６）本実施例は、実施例３により作成した露光用基板を実施例４に基づき作成した露光用マスクを用いた半導体装置の製造方法に関するもので、コンタクトをとるためのホールパターンを作成するための手法である。

【０１４０】被加工基板上にＫｒＦエキシマレーザに感光性を有する感光性樹脂材料を膜厚約１μｍで形成した。この基板に光軸を含み光軸を中心に持つ円形の照明を実施例４記載の露光用マスクに入射し、その像を被加工基板上に結像させた。

【０１４１】露光の後、ウエットによる現像を行いレジストパターンを形成した。本手法により、０．３０μｍのホールパターンを焦点位置±０．８μｍの範囲で寸法変動±０．０３μｍ以内に、チップ面内で作成することができた。なお、従来法で作成した位相差と透過率の面内精度が悪いマスクを用いた場合には、０．３０μｍパターンを焦点位置±０．５μｍの範囲でしかチップ面内で寸法変動±０．０３０μｍ以内で作成できなかった。この原因は、周囲で位相差が１８０度でないため、焦点位置の変化が生じると共に焦点深度が小さくなったためである。

【０１４２】本実施例で示したように、本発明により作成した露光マスクを用いることで被加工基板上で幅広い焦点深度を得ることが可能で、このようなマスクを工程の少なくとも一部に用いることで電気的特性（抵抗値、電流値）が非常に均一なマスクを作成することができた。

【０１４３】本露光方法はホールパターンに限るものではなく、孤立ラインパターン，孤立スペースパターンに対しても大変有効であった。

【０１４４】なお、本発明は上述した各実施例に限定されるものではなく、その要旨を逸脱しない範囲で、種々変形して実施することができる。

【０１４５】

【発明の効果】以上詳述したように本発明によれば、半透明膜の膜厚の違いに応じて組成比を調整するなどして複素屈折率を調整することで、基板面内で均一な位相差と強度透過率を得ることができ、このような露光用マス

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クを用いて被加工基板に露光用マスク像を転写し、それを加工することで、電気的特性に対して精度の良い半導体装置を得ることができる。

【図面の簡単な説明】

【図１】単層半透明位相シフト膜の膜厚に対する屈折率と消衰係数の関係を示す図。

【図２】理想的な成膜状態で得られる半透明膜の膜厚分布を示す図。

【図３】理想的な成膜状態で得られる屈折率と消衰係数分布を示す図。

【図４】理想的な成膜状態で得られる位相差と透過率分布を示す図。

【図５】現実的に成膜で得られる屈折率と消衰係数分布を示す図。

【図６】現実的に成膜で得られる屈折率と消衰係数分布を示す図。

【図７】現実的に成膜で得られる位相差と透過率分布を示す図。

【図８】第１の実施例における半透明膜の膜厚分布を示す図。

【図９】膜厚が厚い部分に対応した光照射装置の一例を示す図。

【図１０】第１の実施例における屈折率と消衰係数分布を示す図。

【図１１】第１の実施例における位相差と透過率分布を示す図。

【図１２】第２の実施例における半透明膜の膜厚分布を＊

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＊示す図。

【図１３】膜厚が厚い部分に対応した光照射装置の一例を示す図。

【図１４】第２の実施例における屈折率と消衰係数分布を示す図。

【図１５】第２の実施例における位相差と透過率分布を示す図。

【図１６】第３の実施例における半透明膜の膜厚分布を示す図。

【図１７】第３の実施例における屈折率と消衰係数分布を示す図。

【図１８】第３の実施例における位相差と透過率分布を示す図。

【図１９】第４の実施例を説明するための工程断面図。

【図２０】第５の実施例を説明するための工程断面図。

【符号の説明】

１１，２１…被成膜基板（半透明膜が成膜された透光性基板）

１２，２２…膜厚が厚い領域

１３，２３…光照射部（低圧水銀ランプ）

４１…透光性基板

４２…半透明膜

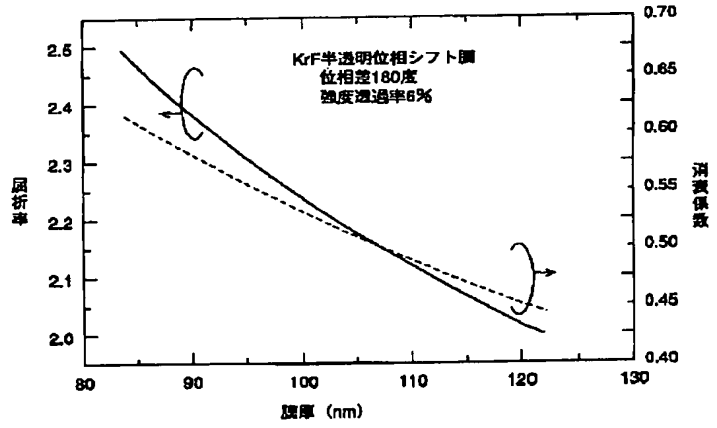
４３…感光性樹脂材料

５１…被加工基板

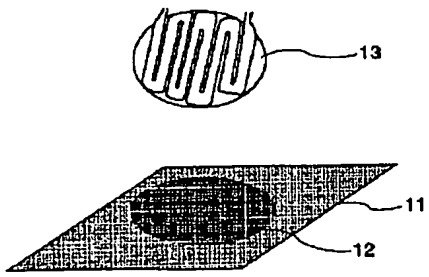
５２…感光性樹脂材料

５３…レンズ

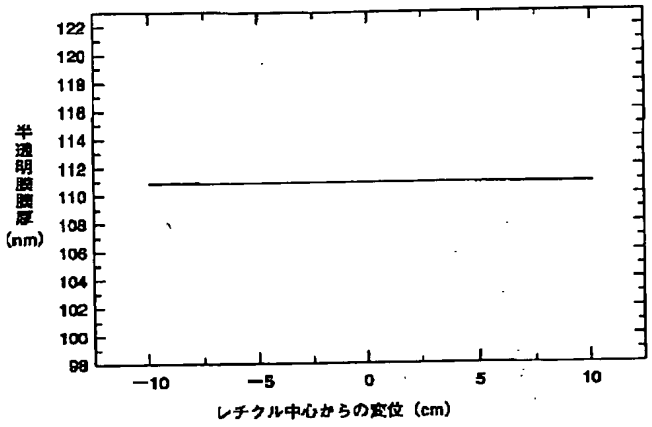
【図１】



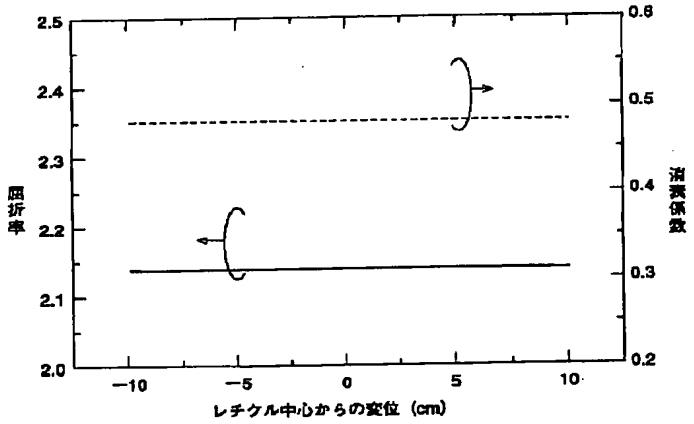
【図９】



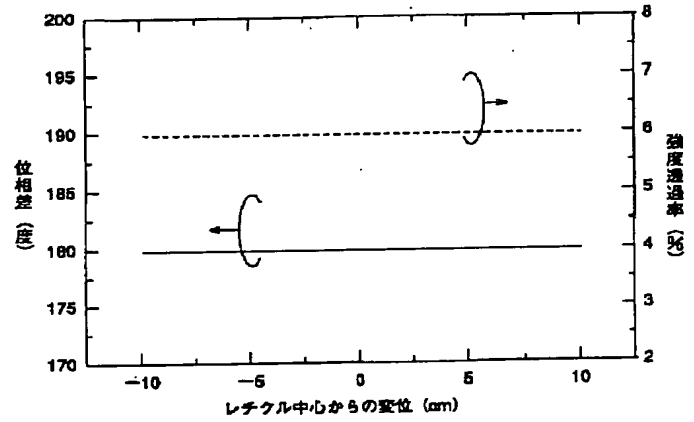
【図２】



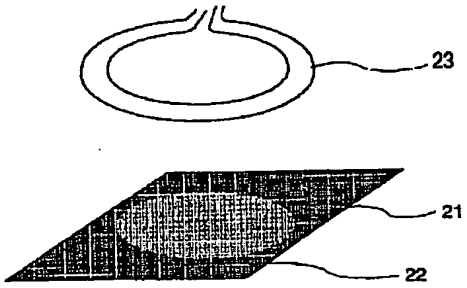
【図３】



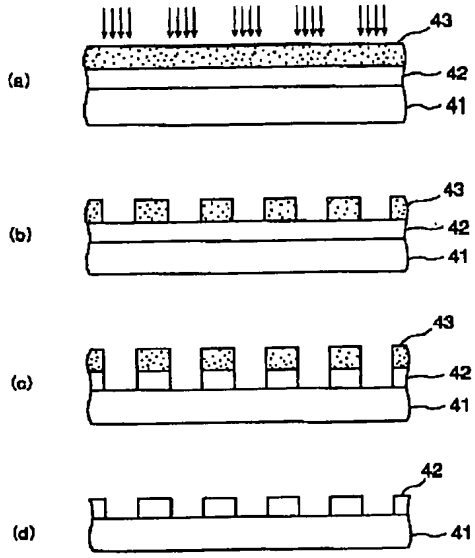
【図４】



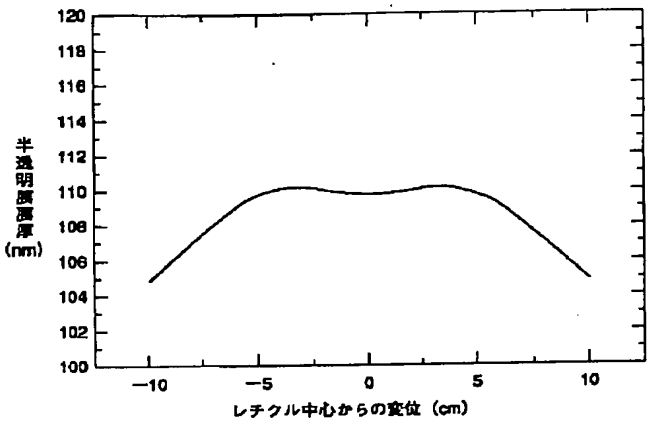
【図１３】



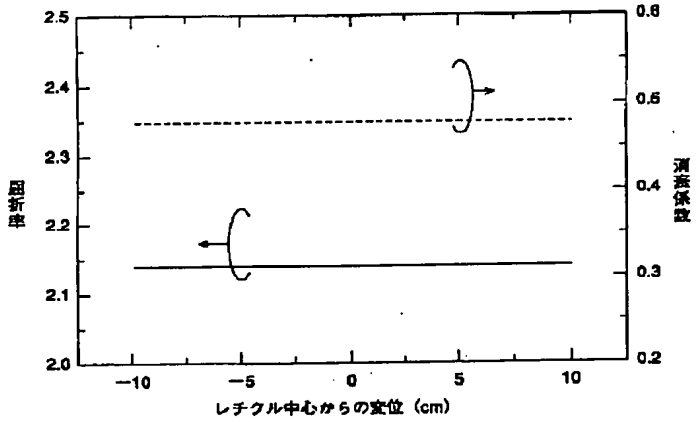
【図１９】



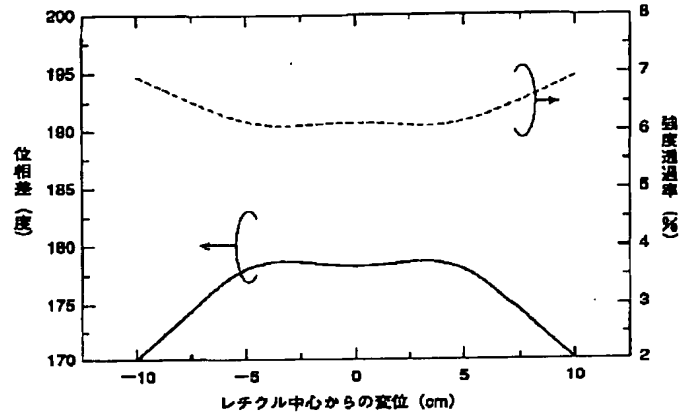
【図５】


半透明膜膜厚 (nm)
120
118
116
114
112
110
108
106
104
102
100
−10
−5
0
5
10
レチクル中心からの変位（cm）

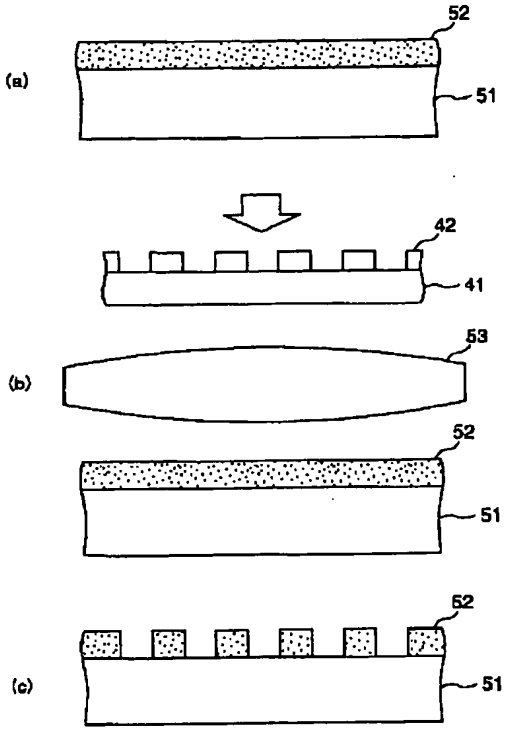
【図６】


屈折率
2.5
2.4
2.3
2.2
2.1
2.0
透過係数
0.6
0.5
0.4
0.3
0.2
−10
−5
0
5
10
レチクル中心からの変位（cm）

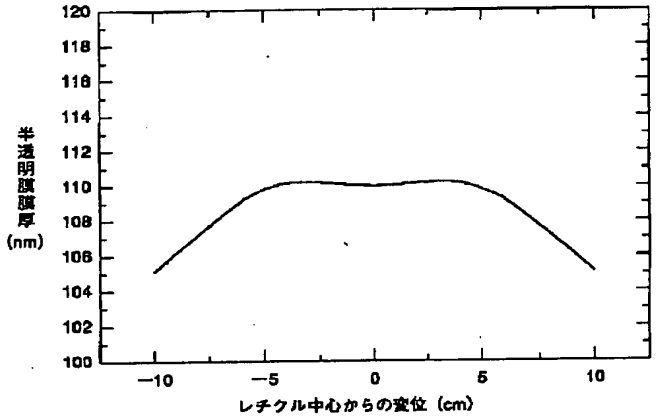
【図７】


位相差（度）
200
195
190
185
180
175
170
強度透過率（%）
8
7
6
5
4
3
2
−10
−5
0
5
10
レチクル中心からの変位（cm）

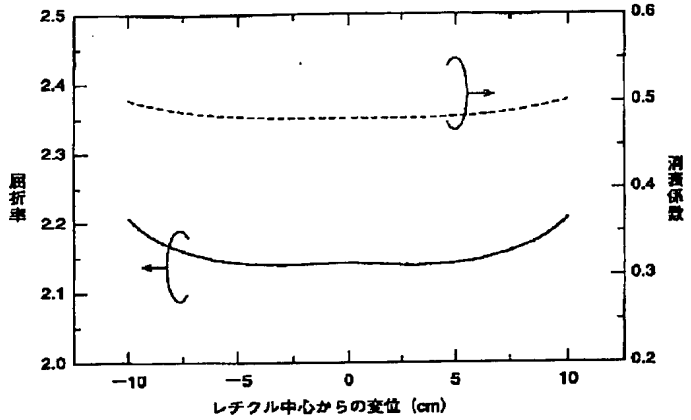
【図２０】


(a)
52
51
42
41
(b)
53
52
51
(c)
52
51

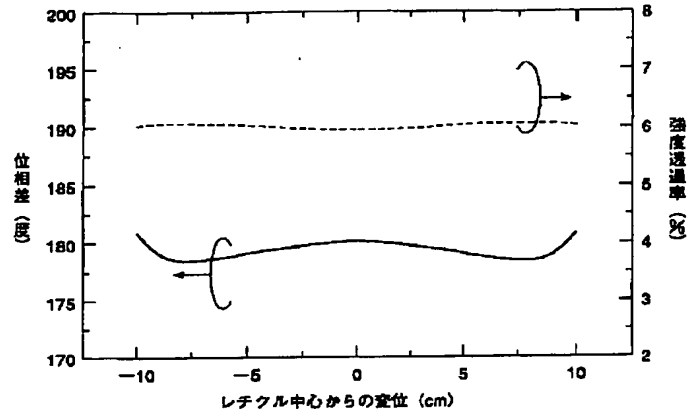
【図８】


半遮明膜膜厚 (nm)
120
118
116
114
112
110
108
106
104
102
100
−10
−5
0
5
10
レチクル中心からの変位（cm）

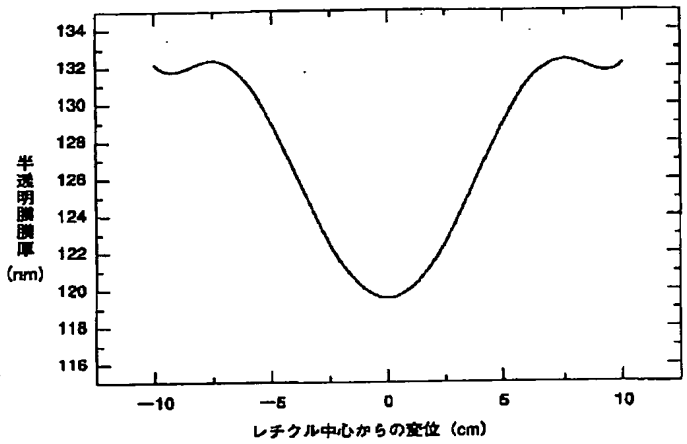
【図１０】


屈折率
2.5
2.4
2.3
2.2
2.1
2.0
消衰係数
0.6
0.5
0.4
0.3
0.2
−10
−5
0
5
10
レチクル中心からの変位（cm）

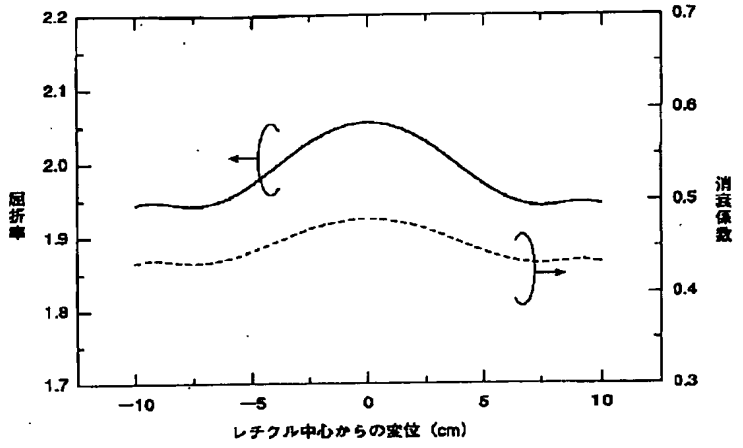
【図１１】


位相差（度）
200
195
190
185
180
175
170
強度透過率（%）
8
7
6
5
4
3
2
−10
−5
0
5
10
レチクル中心からの変位（cm）

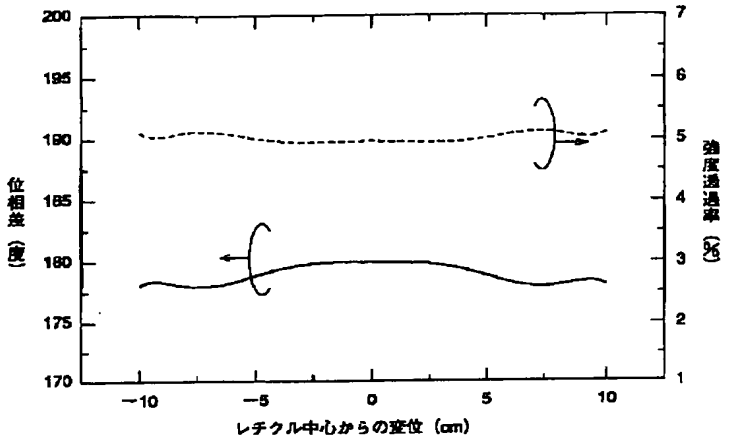
【図１２】


半透明膜膜厚
(nm)
134
132
130
128
126
124
122
120
118
116
−10
−5
0
5
10
レチクル中心からの変位（cm）

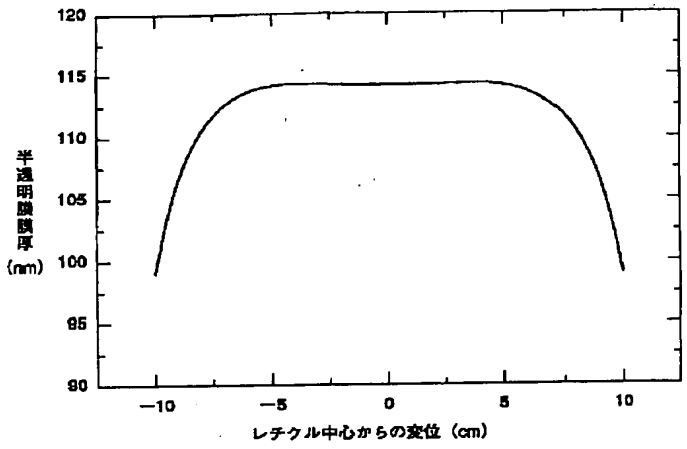
【図１４】


屈折率
2.2
2.1
2.0
1.9
1.8
1.7
消衰係数
0.7
0.6
0.5
0.4
0.3
−10
−5
0
5
10
レチクル中心からの変位（cm）

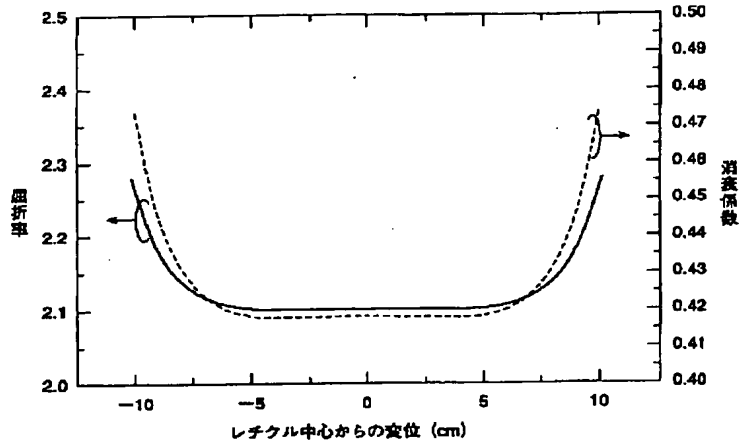
【図１５】


位相差（度）
200
195
190
185
180
175
170
強度透過率（%）
7
6
5
4
3
2
1
−10
−5
0
5
10
レチクル中心からの変位（cm）

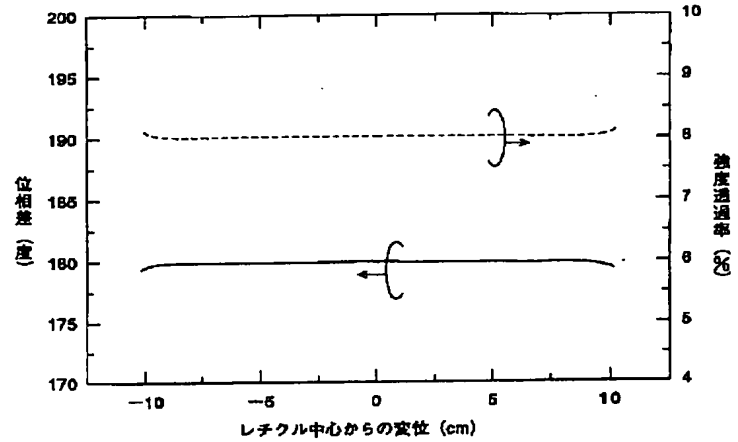
【図１６】


120
115
110
105
100
95
90
半透明膜膜厚 (nm)
−10
−5
0
5
10
レチクル中心からの変位（cm）

【図１７】


2.5
2.4
2.3
2.2
2.1
2.0
屈折率
0.50
0.49
0.48
0.47
0.46
0.45
0.44
0.43
0.42
0.41
0.40
消衰係数
−10
−5
0
5
10
レチクル中心からの変位（cm）

【図１８】


200
195
190
185
180
175
170
位相差（度）
10
9
8
7
6
5
4
強度透過率（%）
−10
−5
0
5
10
レチクル中心からの変位（cm）

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The substrate for exposure with which the complex index of refraction or the elementary composition ratio of said semi-transparent membrane is characterized by coming to be adjusted according to the thickness of this semi-transparent membrane in the substrate for exposure equipped with the semi-transparent membrane which has desired phase contrast and desired permeability to this substrate on a translucency substrate.
[Claim 2] The substrate for exposure according to claim 1 characterized by adjusting the complex index of refraction or the elementary composition ratio of said semi-transparent membrane so that a refractive index and an extinction coefficient may become small in the thick part of the thickness of said semi-transparent membrane, or so that a refractive index and an extinction coefficient may become large in the thin part of the thickness of said semi-transparent membrane.
[Claim 3] The mask for exposure with which the complex index of refraction or the elementary composition ratio of said semi-transparent membrane pattern is characterized by coming to be adjusted according to the thickness of this semi-transparent membrane pattern in the mask for exposure equipped with the semi-transparent membrane pattern which has desired phase contrast and desired permeability to this substrate on a translucency substrate.
[Claim 4] The mask for exposure according to claim 3 characterized by adjusting the complex index of refraction or the elementary composition ratio of said semi-transparent membrane so that a refractive index and an extinction coefficient may become small in the thick part of the thickness of said semi-transparent membrane, or so that a refractive index and an extinction coefficient may become large in the thin part of the thickness of said semi-transparent membrane.
[Claim 5] The manufacture approach of the substrate for exposure which carries out adjustable [of the concentration of gas] by field inboard according to the rate of sedimentation of the semi-transparent membrane to deposit, and is characterized by to adjust the complex index of refraction or the elementary-composition ratio of said semi-transparent membrane in the manufacture approach of the substrate for exposure equipped with the semi-transparent membrane which has desired phase contrast and desired permeability to this substrate on a translucency substrate in case said semi-transparent membrane is deposited on said translucency substrate by the depositing method using reactant gas.
[Claim 6] The manufacture approach of the substrate for exposure according to claim 5 characterized by adjusting the concentration of said reactant gas so that a refractive index and an extinction coefficient may become small in the quick part of the rate of sedimentation of said semi-transparent membrane, or so that a refractive index and an extinction coefficient may become large in the late part of the rate of sedimentation of said semi-transparent membrane.
[Claim 7] The manufacture approach of the substrate for exposure characterized by to include the process which forms said semi-transparent membrane on said translucency substrate, and the process which subsequently irradiates light or reactant gas alternatively at this semi-transparent membrane according to the thickness of said semi-transparent membrane, and adjusts the complex index of refraction or the elementary-composition ratio of said semi-transparent membrane in the manufacture approach of the substrate for exposure equipped with the semi-transparent membrane which has desired phase contrast and desired permeability to this substrate on a translucency substrate.
[Claim 8] The manufacture approach of the substrate for exposure according to claim 7 characterized by adjusting the exposure of said light or gas so that a refractive index and an extinction coefficient may become small in the thick part of the thickness of said semi-transparent membrane, or so that a refractive

index and an extinction coefficient may become large in the thin part of the thickness of said semi-transparent membrane.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention is [0002] about the manufacture approach of the substrate for exposure which has the phase shifter which especially consists of a semi-transparent membrane, the mask for exposure, and the substrate for exposure with respect to the exposure technique used for the lithography process of the production process of semiconductor fabrication machines and equipment.
[Description of the Prior Art] With the advance of semiconductor technology, high integration and detailed-izing of a semiconductor device are being enhanced by semiconductor device ******. On the occasion of manufacture of this semiconductor device, especially the lithography technique is important as an important point of processing. With the current lithography technique, the approach of carrying out projection exposure of the mask pattern on an LSI substrate through contraction optical system is mainly used. It was very difficult for detailed-ization to receive constraint of the exposure wavelength lambda greatly with this lithography technique, and to form the pattern below wavelength. This has optical reinforcement in a field for cross protection to be large and form in as an umbra originally by the pattern which adjoins wavelength by the pattern of this dimension mostly, and it has become a cause that the quantity of light difference of an umbra and a bright section hardly arises. For this reason, when pattern formation was performed on an LSI substrate using the wavelength of arbitration, a stop colander was not obtained for minimum line width in an about 1.4-time dimension to wavelength.
[0003] The minimum line width required of LSI in recent years needs 0.25 micrometers by 64mDRAM in 0.35 micrometers and also 256MdRAM(s), and in order for the conventional lithography technique to realize these dimensions, it will need to cope with [minimum line width / of 0.35 micrometers] the exposure light source by ArF laser about KrF laser and the minimum line width of 0.25 micrometers. Moreover, although development of a corresponding resist is needed when these light sources are used, these resists are still in a research process, and need a remarkable stage for utilization. Although it is not impossible to transpose the exposure light source to EB, either, as compared with the exposure using light, a throughput falls sharply and is not suitable to practicality.
[0004] The technique of promoting detailed-ization came to be considered from these reasons, without changing the exposure wavelength lambda instead of short-wavelength-izing of the conventional exposure light source.
[0005] There is the halftone mold phase shift method for attaining this purpose which does not need a device design change as indicated by the JP,4-136854,A official report as technique. In order to employ the effectiveness of this phase shift method in the maximum efficiently, it is important to optimize the phase contrast theta and the permeability t of the light which penetrated a transparence part and the diffusion shell. Conventionally, the translucent phase shift mask was created by two-layer membrane structure. Phase contrast theta and permeability t were independently controlled by this technique, and creation was easy. however, membrane formation and an etching process are twice required of two-layer structure respectively -- etc. -- that a routing counter increases and when a defect arose on the lower layer film, problems, like correction is difficult had arisen.
[0006] Moreover, by JP,6-75361,A, in order to conquer these faults, the technique of adjusting phase contrast and permeability to coincidence by monolayer is describing. Moreover, in order to satisfy desired phase contrast and desired permeability on the strength to this technique, the translucent phase shift film is formed so that the presentation ratio of a compound may be kept constant. however, since complex index of refraction became the value of about 1 law when it is fixed and a presentation ratio is

created in the substrate side for exposure, when thickness differed, the difference induced the error to direct phase contrast and permeability on the strength, and the problem that the phase contrast precision and on-the-strength permeability precision of a semi-transparent membrane fell had arisen.
[0007]
[Problem(s) to be Solved by the Invention] It is necessary to adjust phase contrast and permeability to a desired value in the translucent phase shift film. In especially forming the translucent phase shift film by the monolayer, as for the combination of the complex index of refraction which satisfies desired phase contrast and desired permeability, only one exists to one thickness. since complex index of refraction became the value of about 1 law when it is fixed and a presentation ratio is created in the substrate side for exposure like a conventional method, when thickness differed, the difference induced the error to direct phase contrast and permeability on the strength, and the problem that the phase contrast precision and on-the-strength permeability precision of a semi-transparent membrane fell had arisen.
[0008] This invention was made in consideration of the above-mentioned situation, and does not depend the place made into the purpose on distribution of thickness, but is to offer in a field the manufacture approach of uniform phase contrast, the substrate for exposure which can obtain permeability, the mask for exposure, and the substrate for exposure.
[0009]
[Means for Solving the Problem] The following configurations are used for this invention in order to solve the above-mentioned technical problem.
[0010] That is, this invention (claim 1) is characterized by adjusting the complex index of refraction or the elementary composition ratio of said semi-transparent membrane according to the thickness of this semi-transparent membrane in the substrate for exposure equipped with the semi-transparent membrane which has desired phase contrast and desired permeability to this substrate on a translucency substrate.
[0011] Moreover, this invention (claim 3) is characterized by coming to adjust the complex index of refraction or the elementary composition ratio of said semi-transparent membrane pattern according to the thickness of this semi-transparent membrane pattern in the mask for exposure equipped with the semi-transparent membrane pattern which has desired phase contrast and desired permeability to this substrate on a translucency substrate.
[0012] In these invention, it is desirable to include the following gestalt.
[0013] (1) He is trying for adjustment of said complex index of refraction to attain by giving the reactant gas distribution in membrane formation equipment so that it may correspond to a membrane formation rate at the time of membrane formation. About the distribution approach of reactant gas, it is desirable to take one of technique in next.
[0014] (1-1) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20%
[when it is gas by which it has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen, nitrogen, fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become high in a part with a quick membrane formation rate as compared with other parts.
[0015] (1-2) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20%
[when it is gas by which it has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen, nitrogen fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become high in a part with a quick membrane formation rate as compared with other parts.
[0016] (1-3) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20%
[when it is gas by which it has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen or fluorine] He is trying to set up so that the concentration of said reactant gas may become high in a part with a quick membrane formation rate as compared with other parts.
[0017] (1-4) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20%

[when it is gas by which it has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane and said reactant gas contains oxygen, nitrogen, fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become low in a part with a quick membrane formation rate as compared with other parts.

[0018] (1-5) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen, nitrogen, fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become low in a part with a quick membrane formation rate as compared with other parts.

[0019] (1-6) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen or fluorine] He is trying to set up so that the concentration of said reactant gas may become low in a part with a quick membrane formation rate as compared with other parts.

[0020] (2) He is trying to attain by giving the temperature distribution in the substrate for exposure so that adjustment of said complex index of refraction may heat-treat at least at the time of membrane formation and may correspond to thickness. About temperature distribution, it is desirable to take one of technique in next.

[0021] (2-1) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20%, he is trying to give an elevated-temperature part in the thick part of thickness as compared with other parts.

[0022] (2-2) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20%, he is trying to give an elevated-temperature part in the thick part of thickness as compared with other parts.

[0023] (2-3) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20%, he is trying to give an elevated-temperature part in the thick part of thickness as compared with other parts.

[0024] (3) He is trying for adjustment of said complex index of refraction to attain by giving reactant gas distribution within a processor in the processing after forming membranes at least, so that it may correspond to the thickness at the time of membrane formation. About the distribution approach of reactant gas, it is desirable to take one of technique in next.

[0025] (3-1) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen, nitrogen, fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become high in a part with thick thickness as compared with other parts.

[0026] (3-2) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen, nitrogen fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become high in a part with thick thickness as compared with other parts.

[0027] (3-3) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen or fluorine] He is trying to set up so that the concentration of said reactant gas may become high in a part with thick

thickness as compared with other parts.
[0028] (3-4) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane and said reactant gas contains oxygen, nitrogen, fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become low in a part with thick thickness as compared with other parts.
[0029] (3-5) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen, nitrogen, fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become low in a part with thick thickness as compared with other parts.
[0030] (3-6) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen or fluorine] He is trying to set up so that the concentration of said reactant gas may become low in a part with thick thickness as compared with other parts.
[0031] (4) He is trying to attain by giving the temperature distribution in the substrate for exposure so that adjustment of said complex index of refraction may heat-treat after membrane formation at least and may correspond to thickness. About temperature distribution, it is desirable to take one of technique in next.
[0032] (4-1) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20%, he is trying to give an elevated-temperature part in the thick part of thickness as compared with other parts.
[0033] (4-2) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20%, he is trying to give an elevated-temperature part in the thick part of thickness as compared with other parts.
[0034] (4-3) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20%, he is trying to give an elevated-temperature part in the thick part of thickness as compared with other parts.
[0035] (5) He is trying to attain by giving the exposure distribution in the substrate for exposure so that adjustment of said complex index of refraction may perform optical exposure processing after membrane formation at least and may correspond to thickness. About exposure wavelength and exposure distribution, it is desirable to take one of technique in next.
[0036] (5-1) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20%, he irradiates light 365nm or less, and is trying for an exposure to increase in the thick part of thickness as compared with other parts.
[0037] (5-2) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20%, he irradiates light 248nm or less, and is trying for an exposure to increase in the thick part of thickness as compared with other parts.
[0038] (5-3) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20%, he irradiates light 248nm or less, and is trying for an exposure to increase in the thick part of thickness as compared with other parts.
[0039] (6) He is trying for adjustment of said elementary composition ratio to attain by adjusting so that it may correspond to the thickness at the time of membrane formation at the time of membrane formation. About the distribution approach of an elementary composition ratio, it is desirable to take one of technique in next.
[0040] (6-1) When the average permeability on the strength within 12cm angle of cores of the substrate

for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20% It has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane. And he is trying to set up so that the presentation ratio to the metal or IV group element of oxygen, nitrogen, fluorine, or hydrogen may become high in a part with a quick membrane formation rate as compared with other parts.

[0041] (6-2) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20% It has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane. And he is trying to set up so that the presentation ratio to the metal or IV group element of oxygen, nitrogen, fluorine, or hydrogen may become high in a part with a quick membrane formation rate as compared with other parts.

[0042] (6-3) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20% He is trying to set up so that it may have the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane and the presentation ratio to the metal or IV group element of oxygen or fluorine may become high in a part with a quick membrane formation rate as compared with other parts.

[0043] (6-4) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20% It has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane. And he is trying to set up so that the presentation ratio to the metal or IV group element of oxygen, nitrogen, fluorine, or hydrogen may become low in a part with a quick membrane formation rate as compared with other parts.

[0044] (6-5) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20% It has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane. And he is trying to set up so that the presentation ratio to the metal or IV group element of oxygen, nitrogen, fluorine, or hydrogen may become low in a part with a quick membrane formation rate as compared with other parts.

[0045] (6-6) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20% He is trying to set up so that it may have the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane and the presentation ratio to the metal or IV group element of oxygen or fluorine may become low in a part with a quick membrane formation rate as compared with other parts.

[0046] (7) He is trying for adjustment of said elementary composition ratio to attain by giving the reactant gas distribution in membrane formation equipment so that it may correspond to the thickness at the time of membrane formation at the time of membrane formation. About the distribution approach of reactant gas, it is desirable to take one of technique in next.

[0047] (7-1) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen, nitrogen, fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become high in a part with a quick membrane formation rate as compared with other parts.

[0048] (7-2) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by

the presentation of a semi-transparent membrane, and said reactant gas contains oxygen, nitrogen fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become high in a part with a quick membrane formation rate as compared with other parts.

[0049] (7-3) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen or fluorine] He is trying to set up so that the concentration of said reactant gas may become high in a part with a quick membrane formation rate as compared with other parts.

[0050] (7-4) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane and said reactant gas contains oxygen, nitrogen, fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become low in a part with a quick membrane formation rate as compared with other parts.

[0051] (7-5) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen, nitrogen, fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become low in a part with a quick membrane formation rate as compared with other parts.

[0052] (7-6) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen or fluorine] He is trying to set up so that the concentration of said reactant gas may become low in a part with a quick membrane formation rate as compared with other parts.

[0053] (8) He is trying for adjustment of said elementary composition ratio to attain by adjusting so that it may correspond to the thickness at the time of membrane formation after membrane formation. About the distribution approach of an elementary composition ratio, it is desirable to take one of technique in next.

[0054] (8-1) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20% It has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane. And he is trying to set up so that the presentation ratio to the metal thru/or IV group element of oxygen, nitrogen, fluorine, or hydrogen may become high in a part with thick thickness as compared with other parts.

[0055] (8-2) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20% It has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane. And he is trying to set up so that the presentation ratio to the metal thru/or IV group element of oxygen, nitrogen, fluorine, or hydrogen may become high in a part with thick thickness as compared with other parts.

[0056] (8-3) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20% He is trying to set up so that it may have the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane and the presentation ratio to the metal or IV group element of oxygen or fluorine may become high to a part with thick thickness as compared with other parts.

[0057] (8-4) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20% It has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane. And he is trying to set up so that the presentation ratio to the metal thru/or IV group element of oxygen, nitrogen, fluorine, or hydrogen may become low in a part with thick thickness as compared with other parts.
[0058] (8-5) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20% It has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane. And he is trying to set up so that the presentation ratio to the metal thru/or IV group element of oxygen, nitrogen, fluorine, or hydrogen may become low in a part with thick thickness as compared with other parts.
[0059] (8-6) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20% He is trying to set up so that it may have the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane and the presentation ratio to the metal or IV group element of oxygen or fluorine may become low to a part with thick thickness as compared with other parts.
[0060] (9) He is trying to attain because adjustment of said elementary composition ratio exposes into a reactant gas ambient atmosphere at least and gives distribution to said reactant gas so that it may correspond to the thickness at the time of membrane formation after membrane formation. About the distribution approach of reactant gas, it is desirable to take one of technique in next.
[0061] (9-1) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen, nitrogen, fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become high in a part with thick thickness as compared with other parts.
[0062] (9-2) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen, nitrogen fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become high in a part with thick thickness as compared with other parts.
[0063] (9-3) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become small because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen or fluorine] He is trying to set up so that the concentration of said reactant gas may become high in a part with thick thickness as compared with other parts.
[0064] (9-4) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 365nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane and said reactant gas contains oxygen, nitrogen, fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become low in a part with thick thickness as compared with other parts.
[0065] (9-5) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 248nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient

become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen, nitrogen, fluorine, or hydrogen] He is trying to set up so that the concentration of said reactant gas may become low in a part with thick thickness as compared with other parts.

[0066] (9-6) When the average permeability on the strength within 12cm angle of cores of the substrate for exposure in the wavelength of 193nm creates the semi-transparent membrane which is 4 - 20% [when it is gas by which it has the property in which a refractive index and an extinction coefficient become large because the presentation ratio of oxygen, nitrogen, fluorine, or hydrogen becomes large by the presentation of a semi-transparent membrane, and said reactant gas contains oxygen or fluorine] He is trying to set up so that the concentration of said reactant gas may become low in a part with thick thickness as compared with other parts.

[0067]

[Function] The conditions and the concrete technique of obtaining the monolayer semi-transparent membrane which can acquire desired permeability t and phase contrast theta to opening of a translucency substrate are described about this invention.

[0068] When it is going to use a semi-transparent membrane by the monolayer, it is required to control the phase of the light which penetrates a semi-transparent membrane at 180 degrees to the phase of the light which penetrates a transparent part, and it is required to make the permeability t of a semi-transparent membrane into a desired value.

[0069] In order to obtain the resolution maximum with the phase shift mask of a semi-transparent membrane, the optical constant of a semi-transparent membrane needs to fulfill the following conditions.

[0070] In order to ask for membranous phase contrast theta and membranous permeability t, it is very effective to perform multiplex interference count using a membranous property matrix. Considering the case where set n and an extinction coefficient to k, set thickness to d, and exposure light carries out incidence of the refractive index of a semi-transparent membrane at right angles to a semi-transparent membrane now, the property matrix of a semi-transparent membrane can be expressed like (a formula 1).

[0071]

[Equation 1]

$$[M] = \begin{bmatrix} m11 & m12 \\ m21 & m22 \end{bmatrix} = \begin{bmatrix} \cos\delta & \frac{i\sin\delta}{n-ik} \\ i(n-ik)\sin\delta & \cos\delta \end{bmatrix} \quad (式1)$$

[0072] Here, delta is given like (a formula 2).

[0073]

[Equation 2]

$$\delta = 2\pi n d / \lambda \quad (式2)$$

[0074] This property matrix is used and they are the electric field E0 on the interface of a semi-transparent membrane and a quartz substrate, and a magnetic field H0 further. The electric field E1 on a semi-transparent membrane and an air interface, and magnetic field H1 It uses and is [Equation 3].

$$\begin{bmatrix} E_0 \\ H_0 \end{bmatrix} = [M] \begin{bmatrix} E_1 \\ H_1 \end{bmatrix} \quad (式3)$$

[0075] It can express. By the way, when it takes into consideration that a substrate considers that it is thick enough to the exposure wavelength lambda, and multiplex interference does not arise with a substrate, it is the tangential component of the electromagnetic field of the transmitted wave on the interface close brought from the substrate side E2+ H2+=E2+Y2 When it sets, they are E1 =E2+ and H1 =H2+ from boundary condition. Since it becomes, it is [Equation 4].

$$\begin{bmatrix} E_0^+ + E_0^- \\ (E_0^+ - E_0^-)\, n_0 \end{bmatrix} = [M] \begin{bmatrix} E_2^+ \\ E_2^+ n_2 \end{bmatrix} \quad (式4)$$

[0076] ******. Complex permeability t' can be expressed as (a formula 5) from this.
[0077]
[Equation 5]

$$t' = \frac{E_2'}{E_0'} = \frac{2 n_0}{n_0 (m11 + n_2 m12) + (m21 + n_2 m22)} \quad (式5)$$

[0078] It is [Equation 6] when it furthermore asks for the permeability t on the strength and a phase phi from t.

$$t = (t' の実部)^2 + (t' の虚部)^2 \quad (式6)$$

$$\phi = \tan^{-1} (t' の虚部 / t' の実部) \quad (式7)$$

[0079] ******. Thus, the permeability t and phase contrast theta when applying this semi-transparent membrane to a mask pattern can be searched for by calculating the relative value theta of the permeability t on the strength obtained with the air of the same thickness as the permeability t of a semi-transparent membrane on the strength and the phase phi, and semi-transparent membrane which were obtained, and a phase. In addition, this formula is applicable only to the monolayer translucent phase shift film also about the multilayer translucent (transparent membrane is included in part) phase shift film.
[0080] The result of having asked for the relation of the refractive index and extinction coefficient to the thickness in the case of forming the translucent phase shift film by the monolayer from these formulas is shown in drawing 1 . Drawing 1 is the example of the semi-transparent membrane of 180 phase contrast on condition of using KrF excimer laser for the exposure light source, and 6% of permeability on the strength. If thickness becomes settled as shown in drawing 1 , the refractive index and extinction coefficient for obtaining desired phase contrast and desired permeability on the strength will become settled uniformly.
[0081] When membrane formation of a semi-transparent membrane is performed in the ideal condition, as shown in drawing 2 , thickness becomes fixed [complex index of refraction] in [both] the mask side for exposure, as shown in drawing 3 , but as shown in drawing 4 in this case, it becomes a value with a phase and permeability on the strength fixed in a field. Drawing 4 sets the core of the mask for exposure to 0, and shows the value of the range of **10cm on the basis of this point. As shown in this drawing, when ideal, it is possible to obtain uniform phase contrast and permeability on the strength with the whole mask for exposure.
[0082] However, generally in membrane formation of the translucent phase shift film, the heterogeneity of thickness arises in a substrate side. For example, although the thickness distribution when forming membranes by the spatter was shown so that drawing 5 might apply a magnetic field on a concentric circle and it might become 180 phase contrast and 6% of permeability on the strength centering on a substrate, thickness is thicker than a substrate core in an outside part a little, and it has the inclination for thickness to become thin outside further. When thickness has distribution of drawing 5 and it has uniform complex-index-of-refraction distribution like drawing 6 , the substrate side internal division cloth (when not refusing **10cm** and especially the following, it considers as the field internal division cloth of this field) of phase contrast and permeability turns into distribution like drawing 7 .
[0083] By drawing 7 , phase contrast has -ten distribution 180 degrees, and permeability on the strength has 6+1% of distribution. By the conventional technique, the substrate side internal division cloth for exposure of phase contrast and permeability on the strength suited the inclination for which it depends on thickness fluctuation greatly.
[0084] adjusting complex index of refraction on the other hand, so that it may correspond to thickness fluctuation in this invention -- phase contrast -- the phase contrast within 180**2.5 degrees, and 6% **0.25% and the substrate side of permeability on the strength -- average phase contrast -- receiving -- the range of **2.5 degrees -- moreover, it made it possible to store the permeability on the strength within a substrate side in the range of **2.5 degrees to an average transmission coefficient.
[0085] Adjusting complex index of refraction here so that it may correspond to thickness says making complex index of refraction smaller [than criteria thickness] (both a refractive index and an extinction coefficient small) than the value in criteria thickness in the thick part of thickness, or making complex

index of refraction larger [than criteria thickness] (both a refractive index and an extinction coefficient greatly) than the value in criteria thickness in the thin part of thickness to the criteria thickness of arbitration to the criteria thickness of arbitration.

[0086]

[Example] Hereafter, this invention is explained to a detail using an example.

[0087] (Example 1) This example is a relating-with substrate for exposure using SiNx film (x is presentation ratio of arbitration) applied to semi-transparent membrane at g line, i line, KrF line, etc. thing, is divided here and explains the manufacture approach of the exposure substrate for KrF.

[0088] Si was used as the target on the quartz substrate, and membranes were formed by making the mixed gas of an argon and nitrogen into carrier gas. In the target, the magnetic field was applied so that a spatter might arise in the shape of a ring. Although the membraneous quality at the time of membrane formation was able to obtain complex-index-of-refraction 2.25(refractive index)-0.54(extinction coefficient) i of homogeneity mostly in the substrate side, thickness showed distribution which becomes thin by the periphery as shown in drawing 8 . When the phase contrast within a substrate side and distribution of permeability were searched for from such complex index of refraction and thickness, centering on the substrate, the inclination for permeability to be low large again was acquired for phase contrast reflecting distribution of thickness.

[0089] In order to abolish such phase contrast and distribution of permeability, the translucency substrate which formed membranes was exposed to the bottom of a low-pressure mercury lamp. This processing used for the wavelength of a low-pressure mercury lamp what uses 252nm and 187nm as a principal component for the purpose of reducing the refractive index of a part and all of an extinction coefficient by which light was irradiated. The change by optical exposure was what the uncombined kind (dangling bond) which exists in a semi-transparent membrane absorbs the light of the wavelength contained in the absorption band, and depends the number of dangling bonds on lessening by joining together.

[0090] It was made for an exposure to increase in the thick part of thickness as a low-pressure mercury lamp, using what the thick part 12 of the thickness of the substrate 11 formed membranes was made to correspond, and bent the discharge tube 13 for 12cm around, as shown in drawing 9 .

[0091] The field internal division cloth of the complex index of refraction after performing this processing is shown in drawing 10 . Before the exposure, the complex index of refraction which was uniform in the field is after an exposure, and was able to be made smaller than other fields in the field of **5cm of cores. When the permeability and phase contrast of a semi-transparent membrane were measured in the complex index of refraction shown by drawing 10 and drawing 8 , and the same location which measured thickness, the result of drawing 11 was obtained. As shown by drawing 11 , the uniform property (phase contrast: 180-degree **2.5 degrees, **0.2% (6%) of on-the-strength permeability:central value) was able to be acquired in the translucency substrate side.

[0092] By the conventional technique, although control of permeability and phase contrast was difficult between thickness distribution and complex-index-of-refraction distribution in order not to process so that correlation as shown in drawing 1 may be given, processing which produces joint change after membrane formation like this example was able to be performed, and permeability and the precision within a field of phase contrast were able to be raised by giving distribution of the complex index of refraction according to thickness.

[0093] Although membranes were formed by the reactant spatter in this example, it is also possible not to restrict to this and to carry out by other membrane formation approaches, such as CVD and vacuum evaporationo.

[0094] In addition, although this example showed the manufacture approach of the SiNx film Are applicable to the semi-transparent membrane containing a dangling bond instead of what is restricted to this. For example, metals, such as SiOx, SiOxNy, CrOx, CrNx, CrOxNy, AiOx, AlNx, AiOxNy, CaFx, and MgFx, Or the semi-transparent membrane containing the oxide of a semi-conductor, a nitride, an acid nitride, and fluoride, It is applicable also to the semi-transparent membrane containing the oxide of metal silicide, such as MoSiOx, MoSiNx, MoSiOxNy, WSiOx, WSiOxNy, NiSiOx, NiSiNx, and NiSiOxNy, a nitride, an acid nitride, and fluoride. (x and y are the presentation ratio of arbitration) Moreover, as long as the light source used for changing the number of dangling bonds contains the wavelength belonging to some absorption bands [at least] of a semi-transparent membrane, what kind of the light source is sufficient as it. The configuration of the light source is not restricted annularly, either, and if the form of the light source is set up corresponding to thickness distribution, such as a

globular shape and Kushigata, so that an illuminance may become large as thickness becomes thick, the thing of any gestalten is applicable. The light source or a substrate may be core-rotated or change-of-mind rotated during an optical exposure. It is possible also by heating to acquire the same effectiveness. An optical exposure and heating may be combined. Furthermore, as for the processing time of these light exposure and heating, it is [desired complex-index-of-refraction ******] desirable to set up so that desired phase contrast and desired permeability may be filled.

[0095] At this example, although the substrate core described the case where thickness was thick, compared with the perimeter, even when surrounding thickness is thick, it can apply with constituting so that the real part, the imaginary part, i.e., the refractive index, and the extinction coefficient of complex index of refraction may become smaller than the thin part of thickness in a part with thick thickness. Although this example is related with the substrate for KrF exposure, it cannot be restricted to this and can be applied about the semi-transparent membrane to any exposure wavelength including an X-ray etc.

[0096] Moreover, it is applicable also about the substrate with which light-shielding films, such as Cr or MoSi, were formed on the translucency substrate at least at the part. About the substrate for exposure which a light-shielding film possesses under a semi-transparent membrane, it is good to form a semi-transparent membrane according to this example to the substrate for exposure from which the resist was applied to the substrate for exposure with which the light-shielding film was beforehand prepared in the substrate for exposure, light or selection exposure by the electron ray was performed, and the light-shielding film of the unnecessary section was removed. Moreover, after forming a semi-transparent membrane about the substrate for exposure which a light-shielding film possesses according to this example on a semi-transparent membrane, it is good to form a light-shielding film by the spatter or CVD, vacuum evaporationo, etc.

[0097] Moreover, although this example is related with the semi-transparent membrane creation approach which has a uniform phase and uniform permeability within the film, it may be adjusted so that some semi-transparents membrane may become different permeability at least. When adjusting permeability partially, it is possible to attain the light which converged by irradiating locally. Although this processing may be carried out to the substrate creation time for exposure, you may carry out after translucent pattern formation. Thus, as for adjusting permeability partially, it is desirable to apply to an alignment mark with the wafer used within a pattern space in the case of exposure, an alignment mark with a reticle, and the boundary parts of a pattern formation field and an agenesis field.

[0098] In addition, although the target permeability of the mask for exposure was made into 6% in this example, it does not restrict to this, and if it is 4 - 20% of range, it is applicable to any permeability.

[0099] (Example 2) This example is a relating-with substrate for exposure using SiNx film (x is presentation ratio of arbitration) applied to semi-transparent membrane at g line, i line, KrF line, etc. thing, is divided here and explains the manufacture approach of the exposure substrate for KrF.

[0100] Si was used as the target on the quartz substrate, and membranes were formed by making the mixed gas of an argon and nitrogen into carrier gas. In the target, the magnetic field was applied so that a spatter might arise in the shape of a ring. Although the membraneous quality at the time of membrane formation was able to obtain complex-index-of-refraction 2.15(refractive index)-0.6(extinction coefficient) i of homogeneity mostly in the substrate side, thickness showed distribution which becomes thick by the periphery as shown in drawing 12 . When the phase contrast within a substrate side and distribution of permeability were searched for from such complex index of refraction and thickness, centering on the substrate, the inclination for permeability to be high small again was acquired for phase contrast reflecting distribution of thickness.

[0101] In order to abolish such phase contrast and distribution of permeability, the translucency substrate which formed membranes was exposed to the bottom of a low-pressure mercury lamp in the oxygen ambient atmosphere. This processing used for the wavelength of a low-pressure mercury lamp what uses 252nm and 187nm as a principal component for the purpose of reducing the refractive index of a part and all of an extinction coefficient by which light was irradiated. It was what the change by optical exposure absorbs the light of the wavelength by which the uncombined kind (dangling bond) which exists in a semi-transparent membrane is included in the absorption band, and depends the number of dangling bonds on lessening by joining together.

[0102] The thick part 22 of the thickness of the substrate 21 formed membranes is made to correspond, and it was made for an exposure to increase in the thick part of thickness as a low-pressure mercury lamp, using the discharge tube 23 of cyclic structure, as shown in drawing 13 . In addition, the diameter

of a ring is set to 18cm and it was made for thickness to correspond to a thick part.
[0103] The complex index of refraction after performing this processing is shown in drawing 14 . Before the exposure, the complex index of refraction which was uniform in the field is after an exposure, and was able to be made smaller than other fields in the field outside **5cm of cores. When the permeability and phase contrast of a semi-transparent membrane were measured in the same location which measured the complex index of refraction shown in drawing 14 , the result of drawing 15 was obtained. As shown by drawing 15 , the uniform property (phase contrast: 180-degree **2 times, **0.2% (5%) of on-the-strength permeability:central value) was able to be acquired in the translucency substrate side.
[0104] Although control of permeability and phase contrast was difficult in order not to process by the conventional technique so that correlation as shown in drawing 1 between thickness distribution and complex-index-of-refraction distribution may be given Processing to which a presentation or an integrated state is changed after membrane formation like this example is performed, by including many oxygen by the elementary composition ratio according to thickness, i.e., the thick part of thickness, distribution of complex index of refraction was able to be produced and, thereby, permeability and the precision within a field of phase contrast were able to be raised.
[0105] Although membranes were formed by the reactant spatter in this example, it is also possible not to restrict to this and to carry out by other membrane formation approaches, such as CVD and vacuum evaporationo.
[0106] In addition, although this example showed the manufacture approach of the SiNx film Are applicable to the semi-transparent membrane containing a dangling bond instead of what is restricted to this. For example, metals, such as SiOx, SiOxNy, CrOx, CrNx, CrOxNy, AiOx, AlNx, AiOxNy, CaFx, and MgFx, Or the semi-transparent membrane containing the oxide of a semi-conductor, a nitride, an acid nitride, and fluoride, It is applicable also to the semi-transparent membrane containing the oxide of metal silicide, such as MoSiOx, MoSiNx, MoSiOxNy, WSiOx, WSiOxNy, NiSiOx, NiSiNx, and NiSiOxNy, a nitride, an acid nitride, and fluoride. (x and y are the presentation ratio of arbitration) Moreover, as long as the light source used for changing the number of dangling bonds contains the wavelength belonging to some absorption bands [at least] of a semi-transparent membrane, what kind of the light source is sufficient as it. The configuration of the light source is not restricted annularly, either, and if the form of the light source is set up corresponding to thickness distribution, such as a globular shape and Kushigata, so that an illuminance may become large as thickness becomes thick, the thing of any configurations is applicable. The light source or a substrate may be core-rotated or change-of-mind rotated during an optical exposure. It is possible also by heating to acquire the same effectiveness. An optical exposure and heating may be combined. Furthermore, if a request carries out complex index of refraction of the processing time of these light exposure and heating and it is, it is desirable to set up so that desired phase contrast and desired permeability may be filled.
[0107] Although distribution was given to the presentation of oxygen in this example, it does not restrict to this, and using nitrogen, fluorine, hydrogen, etc., distribution can be given about the presentation and the purpose of this application can also be attained.
[0108] What is necessary is just to constitute from this example so that the real part, the imaginary part, i.e., the refractive index, and the extinction coefficient of complex index of refraction may become smaller than the thin part of thickness in a part with thick thickness even when surrounding thickness is thick although the substrate core described the case where thickness was thick, compared with the perimeter.
[0109] Furthermore, when the real part, the imaginary part, i.e., the refractive index, and the extinction coefficient of complex index of refraction become small by raising the presentation of nitrogen, oxygen, fluorine, or hydrogen, it can apply with constituting so that the presentation ratio of nitrogen, oxygen, fluorine, or hydrogen may be raised in the thick part of thickness more relatively than the thin part of thickness.
[0110] Furthermore, what is necessary is just to constitute so that the presentation ratio of nitrogen, oxygen, fluorine, or hydrogen may be lowered in the thick part of thickness more relatively than the thin part of thickness when the real part, the imaginary part, i.e., the refractive index, and the extinction coefficient of complex index of refraction become large by raising the presentation of nitrogen, oxygen, fluorine, or hydrogen.
[0111] Although this example is related with the substrate for KrF exposure, it cannot be restricted to this and can be applied about the semi-transparent membrane to any exposure wavelength including an X-ray etc.

[0112] Moreover, it is applicable also about the substrate with which light-shielding films, such as Cr or MoSi, were formed on the translucency substrate at least at the part. About the substrate for exposure which a light-shielding film possesses under a semi-transparent membrane, it is good to form a semi-transparent membrane according to this example to the substrate for exposure from which the resist was applied to the substrate for exposure with which the light-shielding film was beforehand prepared in the substrate for exposure, light or selection exposure by the electron ray was performed, and the light-shielding film of the unnecessary section was removed. Moreover, after forming a semi-transparent membrane about the substrate for exposure which a light-shielding film possesses according to this example on a semi-transparent membrane, it is good to form a light-shielding film by the spatter or CVD, vacuum evaporationo, etc.

[0113] Moreover, although this example is related with the semi-transparent membrane creation approach which has a uniform phase and uniform permeability within the film, it may be adjusted so that some semi-transparents membrane may become different permeability at least. When adjusting permeability partially, it is possible to attain the light which converged by irradiating locally. Although this processing may be carried out to the substrate creation time for exposure, you may carry out after translucent pattern formation. Thus, it is partially desirable to apply to an alignment mark with the wafer with which adjustment uses transmission within a pattern space in the case of exposure, an alignment mark with a reticle, and the boundary parts of a pattern formation field and an agenesis field.

[0114] In addition, although the target permeability of the mask for exposure was made into 5% in this example, it does not restrict to this, and if it is 4 - 20% of range, it is applicable to any permeability.

[0115] (Example 3) This example is a relating-with substrate for exposure using SiNx film (x is presentation ratio of arbitration) applied to semi-transparent membrane at g line, i line, KrF line, etc. thing, is divided here and explains the manufacture approach of the exposure substrate for i lines.

[0116] Si was used as the target on the quartz substrate, and membranes were formed by making the mixed gas of an argon and nitrogen into carrier gas. In the target, the magnetic field was applied so that a spatter might arise in the shape of a ring. Moreover, mixed gas is introduced and it was made for nitrogen concentration to become high in the core of the substrate formed membranes by making the core of a target, and the core of the substrate formed membranes in agreement from the core of a target.

[0117] In addition, thickness showed distribution which becomes thin by the periphery as shown in drawing 16 . Complex index of refraction acquired the distribution to which a refractive index and an extinction coefficient become low in a core as shown in drawing 17 . When the permeability and phase contrast of a semi-transparent membrane were measured in the same location which measured the complex index of refraction shown in drawing 17 , the result of drawing 18 was obtained. As shown by drawing 18 , the uniform property (phase contrast: 180-degree **1 time, **0.1% (8%) of on-the-strength permeability:central value) was able to be acquired in the translucency substrate side.

[0118] Although control of permeability and phase contrast was difficult in order not to process by the conventional technique so that correlation as shown in drawing 1 between thickness distribution and complex-index-of-refraction distribution may be given By adjusting a presentation or an integrated state like this example at the time of membrane formation, many nitrogen was able to be included by the elementary composition ratio according to thickness, i.e., the thick part of thickness, distribution of complex index of refraction was able to be produced, and, thereby, permeability and the precision within a field of phase contrast were able to be raised.

[0119] Although membranes were formed by the reactant spatter in this example, it is also possible not to restrict to this and to carry out by other membrane formation approaches, such as CVD and vacuum evaporationo.

[0120] In addition, although this example showed the manufacture approach of the SiNx film Are applicable to the semi-transparent membrane containing a dangling bond instead of what is restricted to this. For example, metals, such as SiOx, SiOxNy, CrOx, CrNx, CrOxNy, AiOx, AlNx, AiOxNy, CaFx, and MgFx, Or the semi-transparent membrane containing the oxide of a semi-conductor, a nitride, an acid nitride, and fluoride, It is applicable also to the semi-transparent membrane containing the oxide of metal silicide, such as MoSiOx, MoSiNx, MoSiOxNy, WSiOx, WSiOxNy, NiSiOx, NiSiNx, and NiSiOxNy, a nitride, an acid nitride, and fluoride. (x and y are the presentation ratio of arbitration) Moreover, you may carry out by the same technique as the after treatment which performed fine tuning of complex index of refraction after the membrane formation shown in the example 1. Furthermore, you may carry out by the same technique as the after treatment which performed fine tuning of a presentation ratio after the membrane formation shown in the example 2.

[0121] Moreover, what is necessary is to give the chamber internal division cloth of the reactant gas at the time of membrane formation, or the presentation distribution over each location of a semi-transparent membrane, and just to attain the purpose of this application using the nitrogen contained in the presentation, fluorine, hydrogen, etc., according to the presentation of the semi-transparent membrane which is not going to restrict to this and it is finally going to obtain, corresponding to a membranous ingredient, although distribution was given to the presentation of nitrogen in this example.
[0122] What is necessary is just to constitute so that the real part, the imaginary part, i.e., the refractive index, and the extinction coefficient of complex index of refraction may become smaller than the thin part of thickness in a part with thickness thick even when thickness is thick around although the substrate core stated the case where thickness was thick, compared with the perimeter by this example.
[0123] Furthermore, what is necessary is just to constitute so that the presentation ratio of nitrogen, oxygen, fluorine, or hydrogen may be raised in the thick part of thickness more relatively than the thin part of thickness when the real part, the imaginary part, i.e., the refractive index, and the extinction coefficient of complex index of refraction become small by raising the presentation of nitrogen, oxygen, fluorine, or hydrogen.
[0124] Furthermore, what is necessary is just to constitute so that the presentation ratio of nitrogen, oxygen, fluorine, or hydrogen may be lowered in the thick part of thickness more relatively than the thin part of thickness when the real part, the imaginary part, i.e., the refractive index, and the extinction coefficient of complex index of refraction become large by raising the presentation of nitrogen, oxygen, fluorine, or hydrogen.
[0125] Although this example is related with the substrate for KrF exposure, it cannot be restricted to this and can be applied about the semi-transparent membrane to any exposure wavelength including an X-ray etc.
[0126] Moreover, it is applicable also about the substrate with which light-shielding films, such as Cr or MoSi, were formed on the translucency substrate at least at the part. About the substrate for exposure which a light-shielding film possesses under a semi-transparent membrane, it is good to form a semi-transparent membrane according to this example to the substrate for exposure from which the resist was applied to the substrate for exposure with which the light-shielding film was beforehand prepared in the substrate for exposure, light or selection exposure by the electron ray was performed, and the light-shielding film of the unnecessary section was removed. Moreover, after forming a semi-transparent membrane about the substrate for exposure which a light-shielding film possesses according to this example on a semi-transparent membrane, it is good to form a light-shielding film by the spatter or CVD, vacuum evaporationo, etc.
[0127] Moreover, although this example is related with the semi-transparent membrane creation approach which has a uniform phase and uniform permeability within the film, it may be adjusted so that some semi-transparents membrane may become different permeability at least. When adjusting permeability partially, it is possible to attain the light which converged by irradiating locally. Although this processing may be carried out to the substrate creation time for exposure, you may carry out after translucent pattern formation. Thus, it is partially desirable to apply to an alignment mark with the wafer with which adjustment uses transmission within a pattern space in the case of exposure, an alignment mark with a reticle, and the boundary parts of a pattern formation field and an agenesis field.
[0128] In addition, although the target permeability of the mask for exposure was made into 8% in this example, it does not restrict to this, and if it is 4 - 20% of range, it is applicable to any permeability.
[0129] (Example 4) This example is related with the mask for exposure created using the substrate for exposure created in the examples 1-3.
[0130] First, as shown in drawing 19 (a), after applying the photopolymer ingredient 43 on the translucency substrate 41 with which the semi-transparent membrane 42 was formed and performing baking, it drew by optical exposure. Subsequently, it is CF4 about the semi-transparent membrane 42 exposed as shown in drawing 19 (c) after development removed either the part by which light was irradiated, or the part which is not irradiated, as shown in drawing 19 (b). It removed by the dry etching by the mixed gas of oxygen. Finally, as shown in drawing 19 (d), oxidation removal was performed for the photopolymer ingredient 43 in the oxygen plasma, and the desired mask for exposure was created.
[0131] In addition, it carried out by giving the etching velocity distribution which the optical property embraced so that dry etching could be deleted to homogeneity in a field by this example. Moreover, although optical exposure was used for drawing in this example, it may not restrict to this and electron beam lithography may perform. In this case, although the resist for electron rays is used also for a resist,

the film which consists of conductive ingredients, such as SnO and ITO, as the upper layer or the lower layer of this resist may be prepared.

[0132] It can choose whether to remove etching in different direction according to the purpose, or to remove isotropic.

[0133] Moreover, what is necessary is just to choose the gas conditions of etching according to the quality of the material of a semi-transparent membrane. For example, what is necessary is just to etch by the gas which contains the matter containing a fluorine element at least, when Si is included in a semi-transparent membrane like this example. Moreover, what is necessary is just to etch by the gas which contains the matter containing a chlorine element at least, when Cr is included.

[0134] (Example 5) In processing wiring etc. about the manufacture approach of the semiconductor device using the mask for exposure which created the substrate for exposure created in the example 2 based on the example 4, this example is the technique for creating Rhine or a tooth-space pattern.

[0135] First, as shown in drawing 20 (a), the photopolymer ingredient 52 which has photosensitivity in KrF excimer laser was formed by about 1 micrometer of thickness on the processed substrate 51. To this substrate, as shown in drawing 20 (b), the mask pattern was imprinted into the sightseeing nature resin ingredient 52 using the lens 53. It is a secondary surface of light source, incidence was carried out to the mask for exposure of example 4 publication so that only the light from the specific location of the symmetry might be condensed 4 times to an optical axis, and specifically, image formation of the mask pattern image was carried out on the processed substrate 51. In addition, opening set as the symmetry section 4 times to the optical axis of a secondary surface of light source is constituted so that the direction of a long side and the Rhine & tooth-space section of a minimum pitch may cross at right angles to the part whose at least one pair exists, and at least one side of the rectangle which connects opening which is in the symmetry section 4 times, and is obtained, or a square may come.

[0136] Development depended sentimentally was performed after exposure, and the resist pattern was formed as shown in drawing 20 (c). By this technique, 0.25-micrometer pattern was able to be created in the chip side to less than **0.025 micrometers of dimension fluctuation in the range with a focal location of **1.5 micrometers. In addition, when a mask with bad phase contrast created with the conventional method and precision within a field of permeability was used, 0.25-micrometer pattern has been created by less than **0.025 micrometers of dimension fluctuation in the chip side only in the range with a focal location of **0.7 micrometers. Since phase contrast is not 180 degrees around, this cause is because the depth of focus became small.

[0137] As this example showed, it was possible to have obtained the broad depth of focus on a processed substrate by using the exposure mask created by this invention, and electrical characteristics (resistance, current value, etc.) were able to create the very uniform mask by using such a mask for a part of process [at least].

[0138] Although the lighting diaphragm which has opening 4 times at the axial symmetry section was adopted as the location of the secondary light source in this example, the diaphragm which does not restrict to this and has opening in the axial symmetry section (n is an integer) n times may be used. Moreover, the diaphragm which has annular opening to an optical axis may be used.

[0139] (Example 6) This example is the technique for creating the hole pattern for taking contact about the manufacture approach of the semiconductor device using the mask for exposure which created the substrate for exposure created according to the example 3 based on the example 4.

[0140] The photopolymer ingredient which has photosensitivity in KrF excimer laser was formed by about 1 micrometer of thickness on the processed substrate. Incidence of the circular lighting which it has in this substrate centering on an optical axis including an optical axis was carried out to the mask for exposure of example 4 publication, and image formation of that image was carried out on the processed substrate.

[0141] Development depended sentimentally was performed after exposure and the resist pattern was formed. By this technique, the 0.30-micrometer hole pattern was able to be created in the chip side to less than **0.03 micrometers of dimension fluctuation in the range with a focal location of **0.8 micrometers. In addition, when a mask with bad phase contrast created with the conventional method and precision within a field of permeability was used, 0.30-micrometer pattern has been created by less than **0.030 micrometers of dimension fluctuation in the chip side only in the range with a focal location of **0.5 micrometers. Since phase contrast is not 180 degrees around, this cause is because the depth of focus became small while change of a focal location arises.

[0142] As this example showed, it was possible to have obtained the broad depth of focus on a processed

substrate by using the exposure mask created by this invention, and electrical characteristics (resistance, current value) were able to create the very uniform mask by using such a mask for a part of process [at least].

[0143] This exposure approach is not restricted to a hole pattern, and was very effective also to the isolated Rhine pattern and the isolated tooth-space pattern.

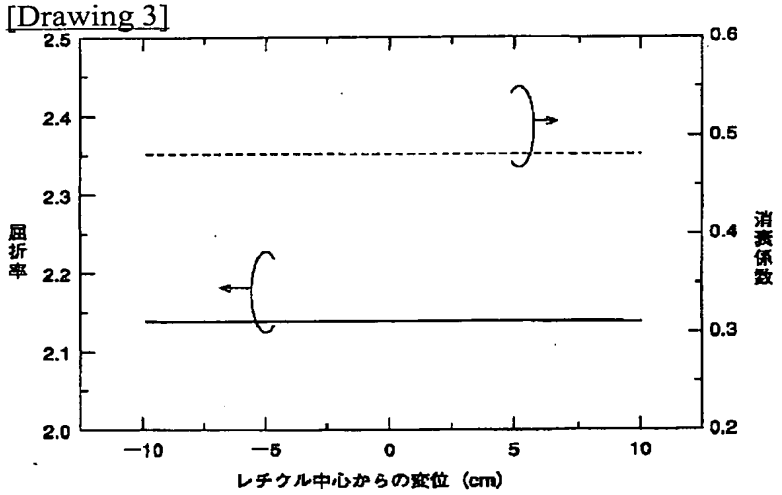
[0144] In addition, this invention is not limited to each example mentioned above, it is the range which does not deviate from the summary, and can deform variously and can be carried out.

[0145]

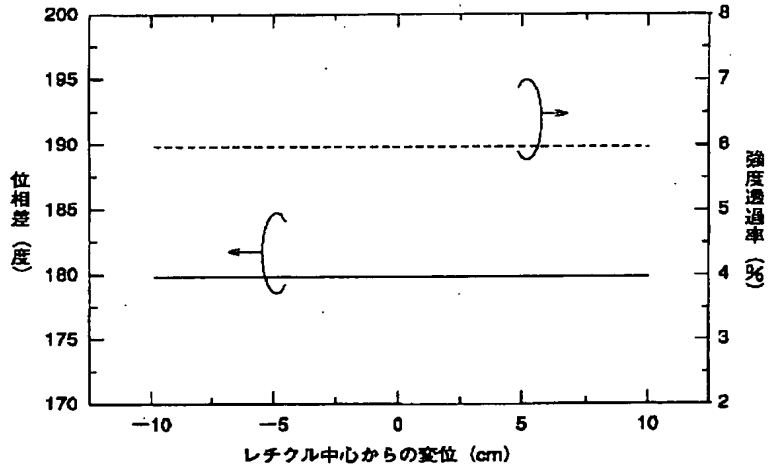
[Effect of the Invention] As explained in full detail above, uniform phase contrast and permeability on the strength can be obtained in a substrate side by according to this invention, adjusting a presentation ratio according to the difference in the thickness of a semi-transparent membrane, and adjusting complex index of refraction, the mask image for exposure can be imprinted to a processed substrate using such a mask for exposure, and an accurate semiconductor device can be obtained to electrical characteristics by processing it.

[Translation done.]

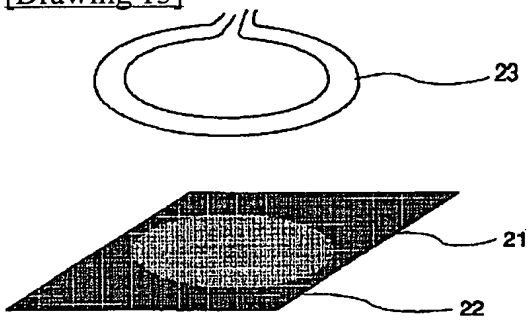
[Drawing 3]



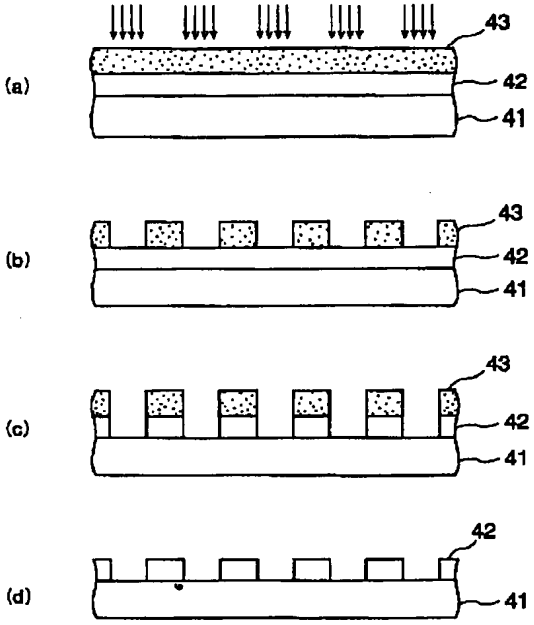
[Drawing 4]



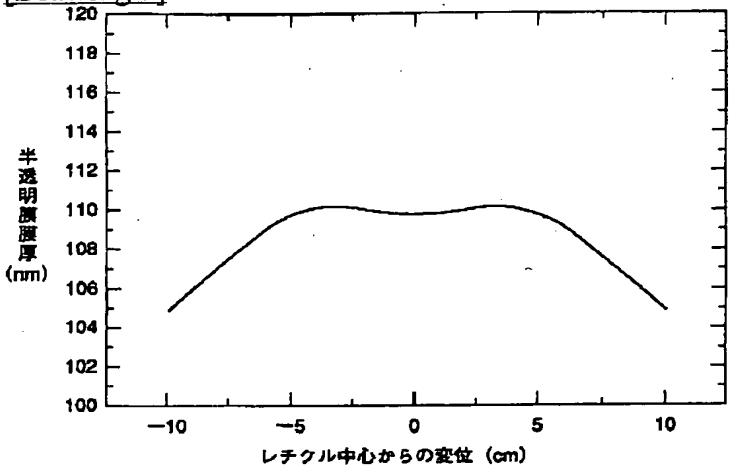
[Drawing 13]



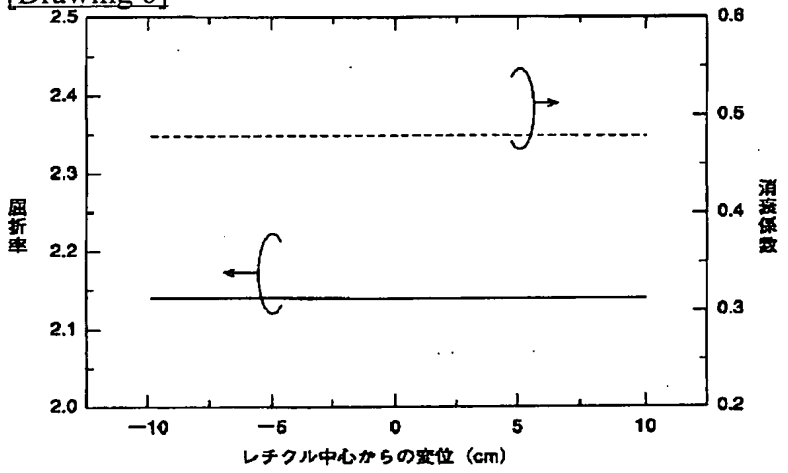
[Drawing 19]



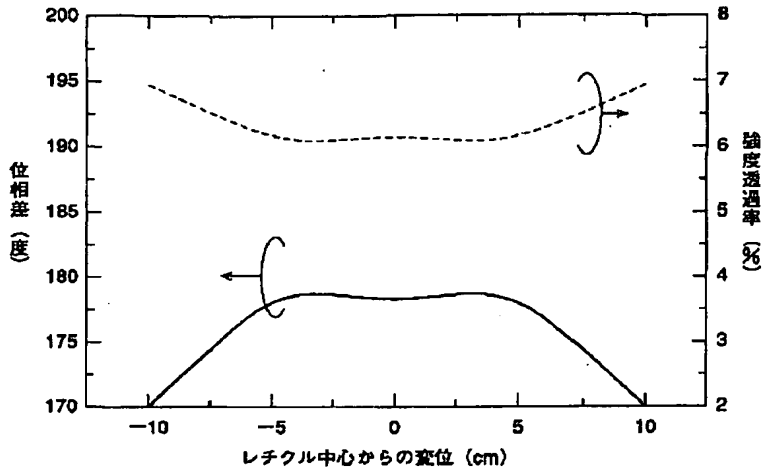
[Drawing 5]



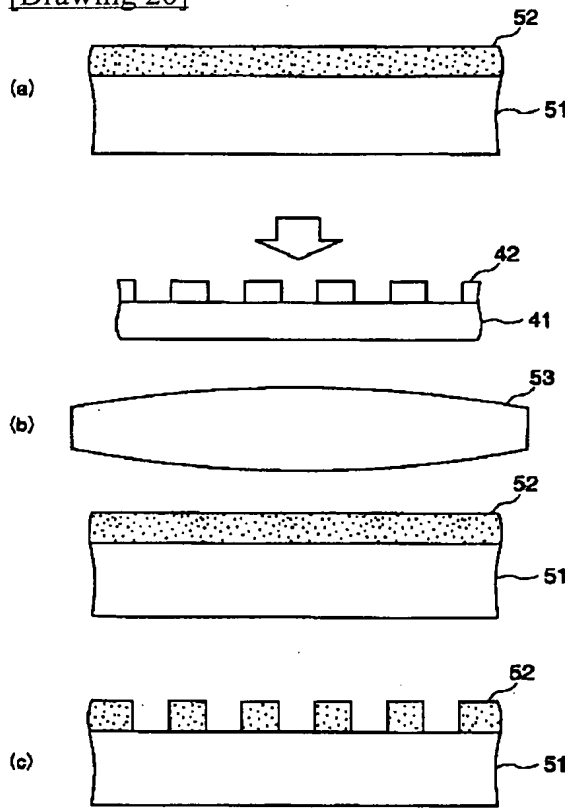
[Drawing 6]



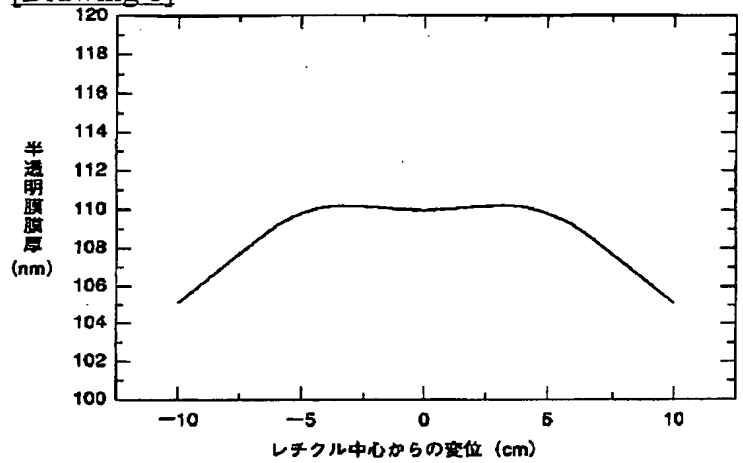
[Drawing 7]



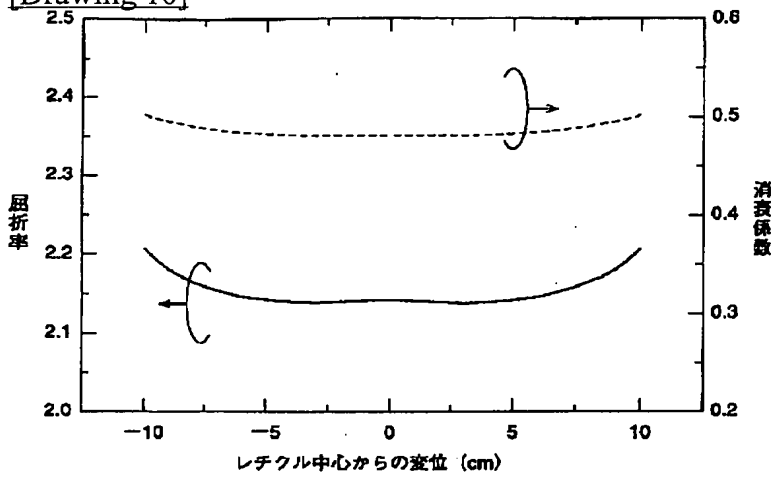
[Drawing 20]



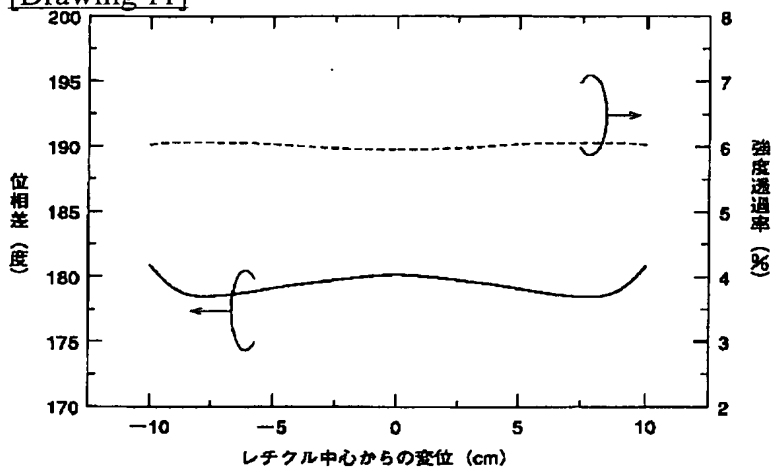
[Drawing 8]



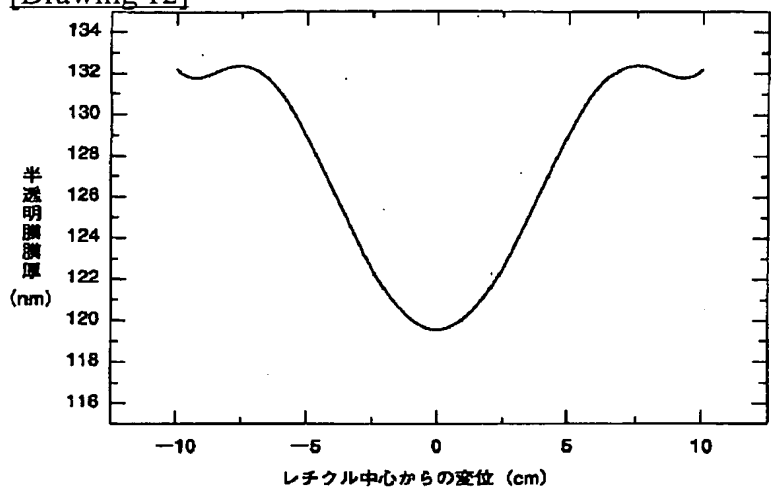
[Drawing 10]



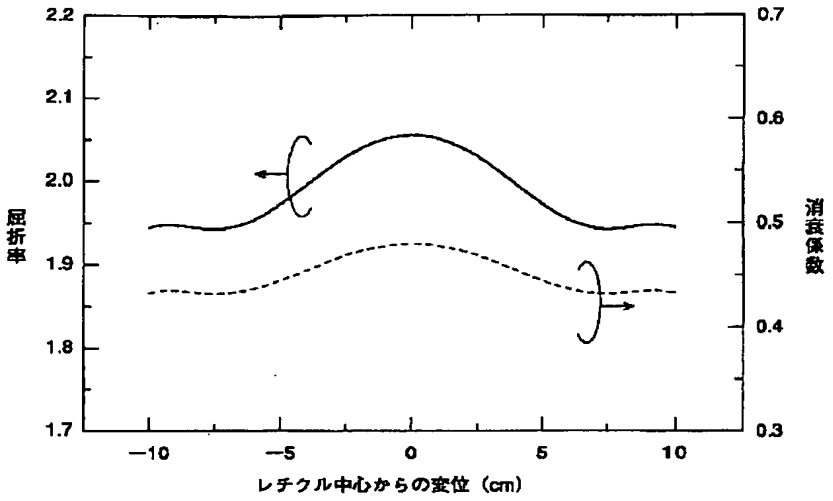
[Drawing 11]



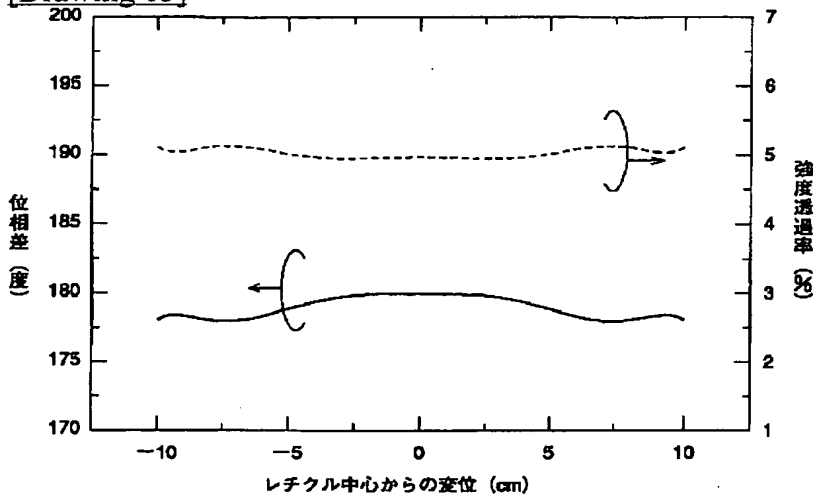
[Drawing 12]



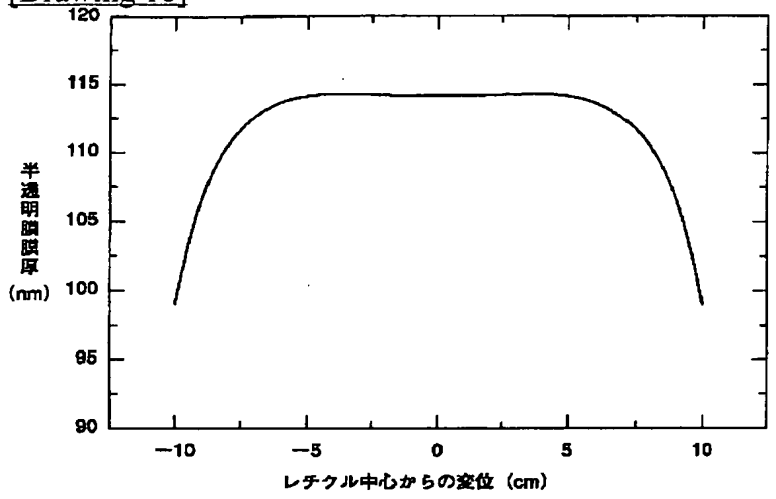
[Drawing 14]



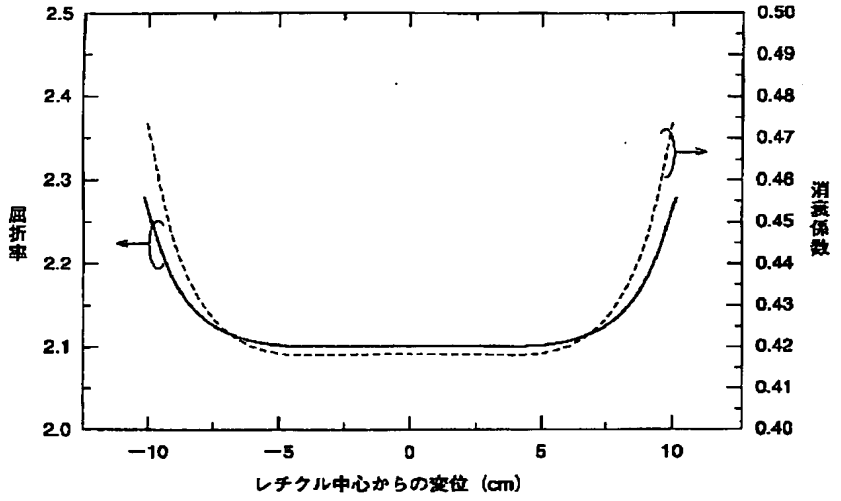
[Drawing 15]



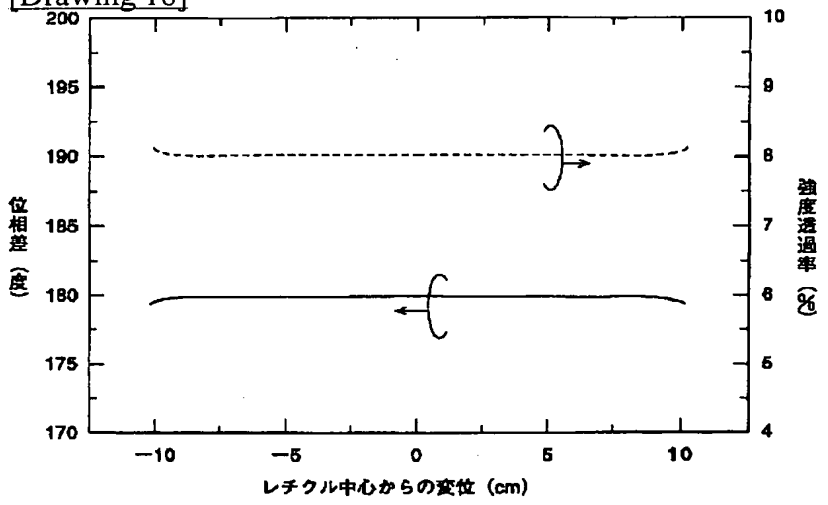
[Drawing 16]



[Drawing 17]



[Drawing 18]



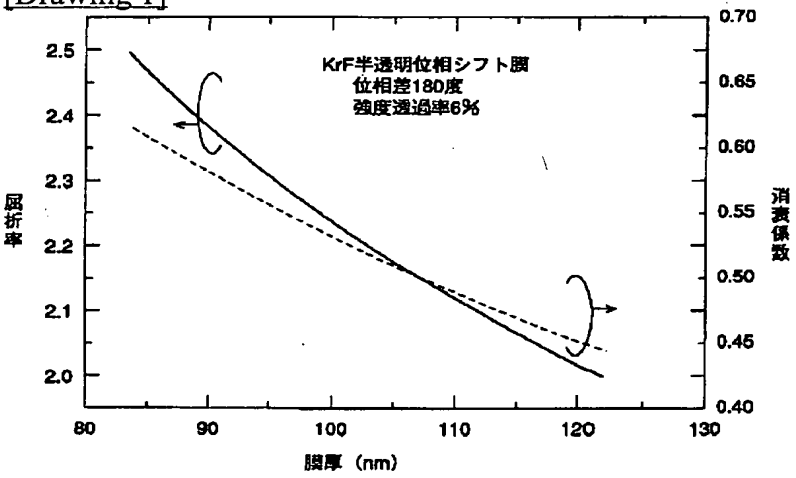
[Translation done.]

* NOTICES *

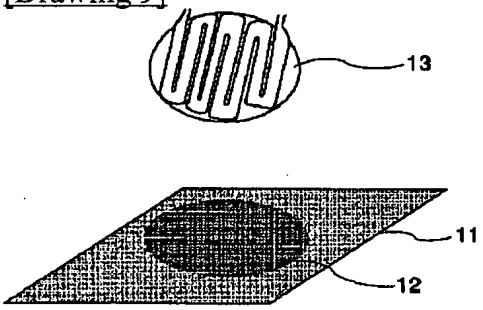
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]



[Drawing 9]



[Drawing 2]